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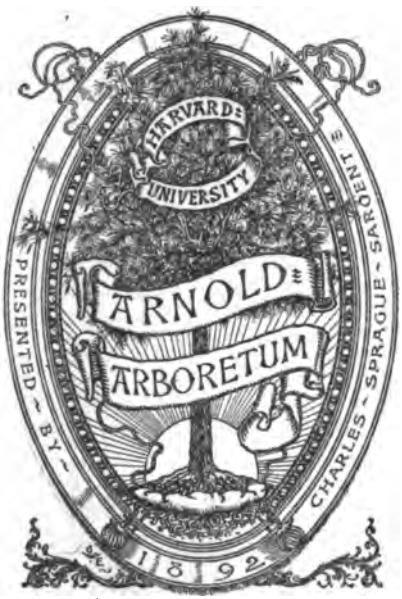
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CONTENTS

1. FRANCIS E. LLOYD. The comparative Embryology of the Rubiaceae. Pp. 1–26. *pl. 1–4.* Issued 26 August 1899; pp. 27–111. *pl. 5–15.* Issued 15 February 1902.

2. ALEXANDER W. EVANS. The Lejeuneae of the United States and Canada. Pp. 113–183. *pl. 16–22.* Issued 15 February 1902.

3. ELIZABETH G. BRITTON and ALEXANDRINA TAYLOR. The Life History of Vittaria lineata. Pp. 185–211. *pl. 23–31.* Issued 30 August 1902.

ERRATA

Page 12, 19th line from top, for mother cell of the embryo sac, read embryo sac cell.

Page 61, 9th line from top, for *megaspore*, read *megaspore mother cell.*

Page 77, 2d line from bottom, for **10**: *252*, read **30**: *221*.

Page 102, 6th line from bottom, for *and*, read *in.*

THE

COMPARATIVE EMBRYOLOGY

OF THE

RUBIACEAE

By

FRANCIS ERNEST LLOYD

Part 1, issued August 26, 1899,
Part 2, issued February 15, 1902.

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

I. INTRODUCTION

The following study was begun during the summer of 1898 in the laboratory of the Botanical Institute in München upon the suggestion and under the direction of Professor K. Goebel. Only a small beginning was made in München on account of a very brief visit—a few weeks only—to that city. Since then the work has been carried on in New York City.

In undertaking a comparative study of the embryology of the Rubiaceae it is expected to gain a knowledge of the life histories of a number of types sufficient to lead to a clearer understanding of the relationships between the genera of a very highly specialized and polymorphous family. It is intended at the same time to extend the studies into the supposedly allied families, and thus to contribute, if possible, to the solution of the more general problems of relationship among the higher dicotyledons.

In addition to the problems of phylogeny there are those which arise out of the physiological relations existing between the sporophyte and the gametophyte. Modern morphology has acquainted us with the main facts in regard to the process of antithetic alternation of generation in the higher plants, and the general physiological relations which are the outgrowth of interdependence of sporophyte and gametophyte. Out of this interdependence, however, a large number of phenomena of both a structural and physiological character have arisen, offering a field of investigation hitherto neglected, to a great extent, but which latterly has been attracting not a little attention. The phenomena of adaptation in this connection are not a whit less interesting if more difficult to observe. In the present study these adaptive phenomena, so far as the writer has succeeded in observing them, will be set forth. It may, however, very properly be borne in mind that these phenomena are chiefly those of nutrition, and the small

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[No. 1, Part I (pp. 1–26), issued August 26, 1899.]

size of the materials makes any other than morphological evidence difficult to obtain. For example, it is argued from appearances that enzymes or at least zymogens are present in the young endosperm, though that such is actually the case is not proven. Since, however, such substances have been shown to be present and have been extracted from, *e. g.*, the young date seedling * and since the action of the sucking organ of that plant on the hard endosperm is due to the ability to secrete the zymogens of a cellulose-dissolving ferment, we have a working basis for such interpretation.

The position here assumed that morphology must be regarded from a physiological point of view is the one emphasized in 1879, by M. Treub in the introductory part of his "Notes sur l'embryogenie de quelques Orchidées,"† where he expressed the hope that the readers of his paper would agree "que la manière dont les embryons absorbent les substances plastiques mérite certainement d'attirer l' attention, et sourtout d'être élucidées lors de recherches embryogéniques." That this point of view was not new with him, Treub took pains, in a detailed historical treatment, to indicate, though it remained for him to adduce the mass of evidence, embodied in the rich work above referred to, which completely substantiates the value of his position. To this historical review the reader is referred for an account of the growth of our knowledge of the suspensor. The succeeding part of the "Notes" deals with the origin, structure and function of the suspensor in eleven genera, including nineteen species of the *Orchidaceae*, in which forms the suspensor is shown to build up for the most part elaborate structures of a haustorial character which serve to absorb nutritive substances to be used by the embryo proper in its development. These structures, which attain the highest degree of specialization in *Herminium monorchis*, *Phalaenopsis grandiflora* and *Stanhopea oculata*, here take the form of tubes ("boyaux") which penetrate into the surrounding tissues of the ovule.

Two years later L. Guignard‡ ('81) published an account of his quite thorough studies on the embryology of the Leguminosae, in

* F. C. Newcombe. Cellulose Enzymes, Ann. Bot. 13 : 49. 1899.

† Nat. Verh. d. K. Akad. van Wet. 19 1879.

‡ Recherches d'embryologie végétale comparée : Embryologie des legumineuses. Ann. sc. nat. Bot. VI. 12 : 5–166. 1881.

many species of which the suspensor attains a morphological character quite as striking as that in the *Orchidaceae*. In the *Viciae* especially the suspensor produces a great number of nuclei sometimes not separated by membranes (*Orobus*). Here, however, the endosperm is scanty and the complex suspensor appears to take its place. Guignard suggests that the principal function of the suspensor may be to contribute to the nutrition of the embryo, but admits at the same time that in certain cases the character of that organ indicates that it serves only as a means of attachment for the embryo.

It is of interest in passing to note that Schleiden and Vogel* ('38) saw the complex suspensor in *Lupinus rivularis*, but interpreted it as a development of the pollen tube in accordance with their then maintained view of the origin of the embryo.

The next work with a distinct physiological bearing dealing especially with the function of the suspensor was by S. H. Koorders† who, in 1892, investigated the embryology of the teak with especial reference to the behavior of the embryo in the matter of nutrition. In this plant a most remarkable condition occurs, which, while entirely analogous to that already found by Treub in certain orchids, was shown by Koorders to be morphologically different. The latter investigator found that the suspensor in its proximal, multicellular part is provided at the close of the "Kogelstadium" with "zuigblasen" or haustoria, which, however, are here special endosperm cells which attach themselves to the suspensor and elongate into tubular structures. Basing his inferences on the distribution of food materials in the ovule and embryo, which he found to be cuticularized till the cotyledonary phase was reached, Koorders concluded, also, that the embryo received nourishment through the agency of the suspensor until the appearance of the cotyledons, after which these organs, especially, are concerned in the absorption of foods through their peripheral membranes.

Touching more especially the rôle of the suspensor there appears to be no further work. The adoption of a similar point of

* Beiträge zur Entwickelungsgeschichte der Blutentheile bei Leguminosen. Verhandl. der K. L.-C. D. Akad. d. Nat. **19**: 60. 1839.

† De Kiemotwickkeling van *Tectona grandis* (Djati). Natuurk. Tijdschr. voor Ned. Ind. III. **12**: 139. *pl. 1–8.* 1892.

view by workers on related matters has been productive of some important publications which we may now with profit glance at briefly.

The first paper, important in this connection, was published by M. Westermaier in 1892, entitled "Zur Embryologie der Phanerogamen insbesondere über die sogenannten Antipoden."* He embraced in his observations something like thirty four species of dicotyledons and monocotyledons, and found in the position and character of the antipodal cells and in the distribution of foodstuffs in the ovule, evidence that the view advocated by Vesque† that the antipodal cells are to be regarded as rudimentary, useless, and of only morphological worth is entirely insufficient to explain the facts, and that, on the contrary, we have here to do with a structure which, while in many cases small and apparently insignificant, are really of very considerable importance in the ultimate nutrition of the embryo. Latterly A. Osterwalder‡ ('98) by the study of *Aconitum Napellus* has established and extended Westermaier's view which he himself in a short note§ again expressed as the result of observations on *Alstroemeria* and other plants.

Mottier's ('93) observations on *Senecio aureus* || and Chamberlain's ('95) on *Aster Novae-Angliae* ¶ extended our knowledge of the antipodals by showing that in these two plants as in some other *Compositae* previously studied by others, a greater number of these cells occur than is usual. This multiplication of antipodal cells is of physiological significance, a view which is strengthened by the observations of D. H. Campbell** ('99) on *Sparganium* and *Lysichiton*, in which these cells are numerous, reaching in the former the number of 150 at least. The author himself suggests that this great development probably indicates an important physiological rôle.

* Verhandl. der K. L.-C. D. Akad. d. Nat. **56**: 1–39. 1892. (The literature previously published regarding the antipodals is found in this paper.)

† "Nouvelles recherches sur le développement du sac embryonnaire des phanérogames angiospermes." Ann. sc. nat. Bot. VI. **8**: 294. 1879.

‡ Beiträge zur Embryologie von *Aconitum Napellus* L. Flora **85**: 254. 1898.

§ Westermaier, Max. "Historische Bemerkungen zur Lehre von der Bedeutung der Antipoden-Zellen." Ber. d. D. B. G. **16**: 214–216. N. 1898.

|| Bot. Gaz. **18**: 245. Jl. 1893.

¶ Bot. Gaz. **20**: 205. My. 1895.

** Bot. Gaz. **27**: 153. Mr. 1899.

The work of perhaps the most interest which has recently appeared is that of Dr. Gabrielle Balicka-Iwanowska † ('99) who has studied the behavior of the embryo-sac in the Scrophulariaceae, Gesneraceae, Pedalinaceae, Plantaginaceae, Campanulaceae, and Dipsaceae. All these forms possess a more or less thickened single integument. Micropylar and chalazal haustoria, which are here for the first time shown to be of endospermic origin, penetrate more or less deeply into the integument which, under such conditions, is said to be devoid of any vascular tissue. Those plants which possess the thickest integument have the most highly developed haustoria, and these in turn have nuclei whose size and appearance show them to be active in nutrition. Their limiting membranes, moreover, are quickly "gelatinized" or become "mucilaginous." The haustoria, in some cases, reach the funicle (*Torenia*) and even the placenta (*Scoparia*). In many species a special nutritive tissue is found in the chalazal region of the ovule and the haustorium is for the most part in direct relation with such tissue. The author does not regard the "tapetes" as merely protective to the embryo-sac, as Hegelmaier held, but holds that they probably secrete a ferment and exercise a digestive function. The antipodal cells, when present, are regarded as having only a less important mission, and are at best evanescent.

While Dr. Balicka-Iwanowska's paper was in preparation at München, Mlle. M. Goldflus* ('99), was engaged in the laboratory of the University of Geneva, in a similar investigation with especial reference to the *Compositae*. Her conclusion as to the physiological value of the "epithelium," the "tapetes" of Balicka-Iwanowska, agrees with that of the latter, an opinion favored, though not fully subscribed to, by Schwere. She furthermore attributes to the antipodal cells considerable importance as agents in nutrition. These cells attain in some of the species studied a considerable size (*Leucanthemum lacustre*, *Chrysanthemum Leucanthemum*, *Helianthus Maximiliani*) and are interpreted as a haustorium (suçoir) inasmuch as they penetrate the axial part of the ovule, and stand in relation with a mass of conductive tissue which

† Contribution à l'étude du sac embryonnaire chez certain Gamopetales. Flora, 86: 47. 1899.

* Sur la structure et les fonctions de l'assise épithéliale et des antipodes chez les Composées. Jour. de Bot. 12: 374. 1898; 13: 9, 47, 87. 1899.

in turn is in a similar relation with the vascular bundle. Mlle. Goldflus bases her opinion not alone on the position of the antipodals, for she finds in the cyanophily of these cells evidence that they represent "l'intermediaire entre le sac embryonnaire et les substances digestibles élaborées par l'ovule."

The *Rubiaceae* in particular have received very little attention. Schleiden * appears to have been the earliest observer whose observations may be regarded as pertinent to the present work. He described the ovule in the *Rubiaceae* as anatropous (gemmula anatropa) and as consisting of a naked nucellus (nucleus nudus), *i. e.*, without any integument (p. 304, *l. c.*). As Warming † points out, it is easily understood how the single thick integument with the very delicate micropylar canal would have misled the earlier observers. These results seem to have remained without modification till the appearance of his "Grundriss," ‡ in which, however, it is further stated (p. 163) that in many *Rubiaceae* the integument remains at least as a thin skin which clings to the endosperm, from which it easily falls off in tatters, as in *Coffea*.

The work of Hofmeister, § as is well known, covered a very large field, and of necessity the treatment of any given group was relatively brief. The results of his work on the *Rubiaceae* are quite brief and faulty. It would, however, be very unfair to criticise him, on account of the difficulties presented by the materials, especially in view of the methods then used, methods which, by the way, in the hands of a master like Hofmeister gave surprising results. According to this pioneer in embryology the antipodals are absent from *Galium*, *Asperula* and *Crucianella*, in which the embryo-sac is attenuated and swollen at the micropyle end. The embryo-sac is quickly filled with endosperm after fertilization has taken place. Within the endosperm, the proembryo develops by forming transverse walls. The cells of a filamentous structure thus formed produce numerous branches made up of short series of cells of which the outer-

* Einige Blicke auf die Entwickelungsgeschichte des vegetabilischen Organismus bei den Phanerogamen. Wiegmann's Archiv. 3: 289, 414. 1837.

† De l'ovule. Ann. sc. nat. Bot. VI. 5: 177. 1878.

‡ Grundriss der Botanik. Leipzig. W. Engelmann, 1850.

§ Neure Beobachtungen über Embryobildung der Phanerogamen. Pringsh. Jahrb. 1: 82. 1858.

most is rounded and swollen. The cells from the middle of these branches send out secondary branches here and there, so that the proembryo as a result of this richness of branching simulates a bunch of grapes. Out of the lower end of this mass projects the primary cell row of the proembryo whose terminal cell develops into the embryo proper. Thus Hofmeister's description of the suspensor in the genera above named, one in the main correct, but requiring modification, as will hereafter be seen. He passes over without criticism and accepts as final the opinion which he attributes to Schleiden that the endosperm breaks through the integument.

In *Houstonia* and *Spermacoce* the embryo-sac is of less slender form and somewhat cylindrical, and here, on the other hand, the antipodal cells are present. The embryo-sac is here also soon filled with endosperm, although the proembryo remains a very simple thread of cells from the last of which the embryo proper arises.

It is unfortunate that no figures of these forms are given so that it is difficult to estimate exactly the value of the author's descriptions.

The only other plant of the *Rubiaceae* which has received any attention is the coffee (*Coffea arabica*), but such work as has been done does not touch upon the ground of the present paper except in a remote way. An account of the literature of this subject may be found in the footnotes of an article by T. F. Hanausek.*

I desire at this point to express my appreciation of the kindness of Professor Ignatius Urban in putting the collection of growing *Rubiaceae* in the Botanical Garden at Berlin at my disposal, and my gratitude to Professor K. Goebel for his generosity in extending to me the courtesy of the laboratory and gardens of the Botanical Institute in München during six weeks of the summer of 1898, and in expending much of his own time in discussion and suggestion when he could ill afford, on account of pressing duties, to do so.

* Ueber symmetrische und polyembryonische Samen von Coffea arabica L. Ber. D. B. G. 13: 73. 1895.

II. DESCRIPTIVE

Vaillantia hispida

Vaillantia is a small genus of the *Galieae* containing only two annual species, indigenous to the Mediterranean region. The plants are monoecious; the flowers are borne in threes supported by a single broadened spiny stalk. Of the three the middle is pistillate, the two lateral staminate. The three-flowered peduncles are in four vertical rows alternate with the four rows of leaves. The regularity and perfect radial symmetry of the species studied render it easy to section a growing tip so as to cut all the ovules of two opposite rows longitudinally.

The material was obtained at the Botanical Garden at Berlin.

THE ORIGIN AND DEVELOPMENT OF THE NUCELLUS

At the period of the development of the pistillate flower when the four corolla lobes have met above the hollowed out receptacles and overarch the stamens, which are as yet merely rounded knobs at the angles of the sinuses of the corolla, four elevations lying in the same vertical plane make their appearance near the base of the ovary. The outer two of these are ridge like, and by their mode of growth meet later in the transverse plane, fuse, extend upwards to form the two styles, and downward to form a partition which divides the originally unilocular ovary into two chambers. The two others are papilliform and lie on either side of the center of the floor of the ovary. These are the nucelli. As they develop, the partition above referred to passes down between them and separates them. The lower edge of the partition finally fuses with the tissues between the funicles of the two ovules, making the ovary bilocular.

We may now turn our attention to the nucellus. For a short time its growth is directly upwards. (Pl. 1. Fig. 1.) There is a well marked epidermis, and the cells are quite filled with dense cytoplasm and large nuclei. More rapid cell division upon the inner side, however, soon causes the apex of the nucellus to be directed toward the floor of the ovary. When the bending of the ovule is complete, and its definitive condition reached, the micropylar

end of the ovule lies in a lower horizontal plane than does the base of the funicle. The micropyle and embryo-sac lie in a curved line, and the funicle remains short. The ovule is therefore not of the strictly anatropous type, but is campylotropous, approaching the anatropous condition. (Pl. 3. Fig. 1.) During the process of inversion the longitudinal axis comes, of course, to lie in the horizontal plane, and about this time a number of the hypodermal cells under the apex of the nucellus elongate in a direction parallel with the longitudinal axis of the nucellus. (Pl. 1. Fig. 2.) These cells, about 12 in number, constitute the archesporial tissue, and are recognizable at first only by their size. Their subsequent changes will be described below. The large number of sporogenous cells here found to constitute the archesporium recalls the condition in *Rubus caesius*, *Geum strictum* and *Sanguisorba officinalis*, in which, according to A. Fischer* ('80) numerous sporogenous cells arise. A similarly large number of these cells has also been found in *Casuarina*,† in *Loranthus*‡ and in *Ranunculus*.§ This character, which appears in several widely separated families is probably therefore not to be regarded as a persistent primitive character in the Rubiaceae at any rate, but one having a physiological meaning, as will be shown later. The sporogenous cells now elongate, and their elongation is accompanied by periclinal division in the epidermis and subadjacent cells of the tissue about the apical part of the nucellus. (Pl. 1. Fig. 3.) Only in the columnar epidermal cells immediately beneath which lie the sporogenous cells there occurs no division, periclinal or otherwise. These, therefore, remain as a cap of cells, about which arises the integument at first as a low ridge, but gradually growing over the nucellar cap and forward so as to form a canal which I shall call the micropylar canal, the outer end of which forms, in the definitive ovule, the micropyle.

The manner in which the integument has its origin recalls vividly the figures by Warming || ('78) of the nucellus of *Thesium*, one of the *Santalaceae*. In the body of the paper the author asks the question "Are these ovules in which the nucellus is not cov-

* Jenaisch. Zeit. f. Nat. 14: 122. 1880.
† Treub, M., Ann. de Buit. 10: 145. 1891.
‡ Treub, M., Ann. sci. nat. Bot. VI. 13: 274. 1882.
§ Coulter, Bot. Gaz. 25: 73. 1898.
|| De l'ovule. Ann. sc. Nat. Bot. VI. 5: 177. 1878.

ered by an integument," and recounts the forms in which, according to earlier students, the nucellus is naked. Some reference to this point has already been made in the introduction. In endeavoring to contribute to the answer of the question, Warming studied the development of the nucellus in the type above mentioned, and found that the epidermal cells at the apex of the nucellus, and therefore, those which cap the elongated cells which lie in the axis of the structure, have contents more granular than the remaining epidermal cells, and also that the epidermal cells surrounding these capping cells divide tangentially and "il se développe ainsi une assez forte couche de cellules de provenance épidermique qu'on doit considérer comme un tégument." His description with the exception of the reference to the more granular contents of the middle epidermal cells is exact enough to apply to the *Galieae*, and one cannot resist the conclusion that his interpretation of this collar of tissue as a rudimentary integument is correct. Guignard, * seven years later, published a fuller account of the behavior of the nucellus and embryo-sac of *Thesium* in which, however, he entirely overlooked Warming's work and suggestion. Guignard here makes no reference to the tangential divisions seen by Warming, nor does he show any such in his figures. Indeed he takes the position (p. 189, l. c.) that there is no integument at all in *Thesium*, though it must be said that in making the statement he is referring to the seed, rather than to the young ovule.

The bottom of the micropylar canal is formed of the few epidermal cells capping the archesporium (Pl. 1, Figs. 5, 6, 8). The walls also are formed by an epidermis continuous with and having its origin in the outer epidermis of the ovule. The endodermis †

* Observations sur les Santalacées. Ann. sc. nat. Bot. VII. 10: 181. 1885.

† This layer has its homologue in the Compositae in the inner cell-layer of the integument which, according to Hegelmaier (Ueber die Keimsack einiger Compositen und dessen Umhüllung. Bot. Zeit. 47: 805, 821. 1889), comes to surround immediately the embryo-sac after its absorption of the nucellus is complete. For this layer Hegelmaier proposed the term *endodermis*, the types under observation and figured being *Helianthus annuus*, *Bidens leucantha* and *Zinnia tenuiflora*. Schwere (Zur Entwickelungsgeschichte der Frucht von *Taraxacum officinalis* Web. Ein Beitrag zur Embryologie der Compositen. Flora 82 : 32. 1896), however, working on *Taraxacum officinalis*, regards the layer surrounding the embryo-sac as having its origin in the outer cell-layer of the nucellus, "bei *Taraxacum* gehört diese Schicht thatsächlich zum Nucellus," a conclusion which is out of harmony with the prevailing view. For this

thus formed does not, however, have the specialized character which has been found to be so common in the *Gamopetalae*. It is not cutinized, and, as will be seen, breaks down very readily under the action of the developing embryo-sac.

Meanwhile the archesporial cells are undergoing considerable changes which will now be described.

At the time of rapid elongation of the nucellus, the archesporial cells, too, increase in length. This is accompanied by a good deal of change in the appearance of their cytoplasm and nuclei. The cytoplasm which at first and for some time is granular, becomes more and more fibrous in appearance. The fibers run approximately lengthwise. The granular character is still visible, but the stringiness becomes more marked as the cells themselves elongate (Pl. 1, Figs. 3–8). When they reach their maximum length they are spindle-shaped and appear to run under and above each other in a most perplexing fashion. Their separating membranes become less and less distinct, until they cannot be made out, and I believe them to be almost, if not entirely, absorbed. The nuclei, too, rapidly increase in size, while the chromatin, granular at first, runs through various changes, unnecessary to describe here, which are preparatory to mitosis.

It should be pointed out here that the nucellar tissue next to the archesporial tissue on its inner side is made up of cells which lengthen much more than those of the rest of the nucellus (Pl. 1, Fig. 5). The innermost of these are, indeed, as a usual thing, as long as the archesporial cells and appear to partake to a great degree of their characters. That the nucellar cells next to the archesporial cells may approach the latter in character has been noted by Coulter (l.c.) in *Ranunculus*. They may without doubt be regarded as underdeveloped sporogenous cells, which in this case disintegrate, while their substance probably contributes to the growth of the archesporium.

When the archesporial cells as above mentioned have reached

layer he proposed the term *endothelium*, a term which is evidently inappropriate. Schwere's figures as to this detail are very unsatisfactory and unconvincing, while it is quite evident from Hegelmaier's drawings that the layer to which he gave the name *endodermis* is in reality what he thought it to be. This layer is, moreover, an *inner* layer, so that *epithelium*, the term adopted by Mlle. Goldflus, seems to me a less appropriate term, because more general.

their greatest elongation, mitosis takes place. I shall take the opportunity of describing the cytological details in a separate paper. For the present purpose it is enough to say that so far as my own observation goes four megaspores result from the division of each primitive cell. The appearance of the mass of cells which results from the division of the archesporial cells is very similar to that presented by similar cells arising in the same manner in *Helianthemum Rhodax* as described and figured by A. Fischer* according to whom two or three "mother cells" are in this form cut off, which divide each into four or sometimes six daughter cells (megaspores) one only of all these resultant cells becoming the mother cell of the embryo-sac, the rest suffering disorganization.

Several or all of the archesporial cells may divide; thus may many megaspores arise, among which there is a considerable discrepency in size (Pl. 1, Fig. 9). Of one quartette arising from one mother cell, the lowest cell may be the largest; in another, one of the middle ones; then again the uppermost may be the largest. I have not been able to determine whether there is any constancy in the selection of a megaspore to be the mother cell of the embryo-sac. The appearance of such material as I have examined seems to favor the opinion that any one of them, but more especially one of the end cells of the quartette, may be chosen.

As a rule only *one* of all the megaspores actually germinates. Exceptionally in other genera to be hereafter described, I have found two embryo-sacs completely formed and lying parallel; one of these usually lies farther forward than the other, and this one is functional.

THE DEVELOPMENT OF THE EMBRYO-SAC

At the completion of megaspore formation, the chosen megaspore commences a migration along the micropylar canal formed as above described by the forward growth of the integument. This migratory movement of the functional megaspore appears to be unique, for I have not been able thus far to find any reference in the literature which shows that such migration has hitherto been observed. The cap of epidermal cells which overlies the archesporium

* Zur Kenntniss der Embryosackentwickelung einiger Angiospermen. Jenaische Zeitschr. 14: 90. 1880.

seems to be a barrier to any such migration, for the migrating megaspore, so far as I have been able to determine, pushes its way to one side, as shown in Pl. 2, Fig. 1. It is reasonable to conclude that these capping cells are in a short time destroyed, for in later stages they are not usually seen. I have seen these cells once in one species of *Galium*, when the embryo-sac was mature.

The nucleus of the migrating megaspore, after passing this barrier, comes to lie in the micropylar canal about midway its length, while the accompanying cytoplasm lies in a thin layer on the walls of the canal, and so forms a large vacuole at each end of the nucleus. The whole megaspore is, roughly speaking, hour-glass-shaped (Pl. 2, Fig. 1), and its nucleus lies at the constriction. The enlarging megaspore encroaches laterally on the integument, which now for the first time is broken down. The endodermis gives way first, and is recognized a little later only by collapsed walls and the nuclei, which are the last elements of the cells to disintegrate. The persistence of nuclear substance under the action of digestive ferments suggests that the tissue which behaves thus is undergoing digestion. This is the view taken by Mlle. Goldflus (*l. c.*) in describing the behavior of the integumental tissue about the base of the embryo-sac in the *Compositae* the internal part of which is dissolved by "ferments secrétés probablement par les cellules epithéliales."

At the constriction in the hour-glass-shaped megaspore the first division of the megaspore nucleus takes place, after which one of the daughter nuclei passes forward to the micropylar end of the cavity. When it reaches this point the second division takes place in both nuclei (Pl. 2, Fig. 2). There are now four. The egg apparatus arises in the usual fashion at the micropylar end (Pl. 2, Fig. 3, 4). In the antipodal region a more unusual state of affairs occurs.

THE ANTIPODAL APPARATUS

The division of the antipodal nuclei, now two in number, results in four, one of which is, in the usual manner, concerned in the formation of the endosperm nucleus. This passes forward to coalesce with the corresponding nucleus from the egg region. Of the three which remain, one enlarges considerably and migrates

backwards towards the chalazal region. Its proper cytoplasm becomes cut off by a transverse wall from the upper part of the embryo-sac (Pl. 2, Fig. 4). The other two antipodal cells surround themselves by walls, and take ultimately a lateral position. They are small and unequal in size and are usually more or less collapsed and apparently of little or no further value; and they overstain in the manner of disintegrating cells. Not so, however, with the odd, basal antipodal, for in these forms (*i. e.*, *Vaillantia*, *Galium*, etc.), it appears to have a distinct and important physiological rôle.

It has been supposed, since the publication of Hofmeister's classical researches on the embryology of the Phanerogams (*l. c.*), that antipodals were absent in those forms of the *Rubiaceae* studied by him, excepting *Houstonia* and *Spermacoce*. I have confirmed Hofmeister's view as to *Houstonia*, but in addition I am prepared to show that antipodal cells are present in all *Rubiaceae* up to this time studied by me. The smallness of the structures in these plants, and especially the attenuated character of the basal antipodal, together with the similarity of the other two to the adjoining disintegrating integumental cells will readily account for the oversight.

The basal antipodal cell is composed at first of cytoplasm which is tenuous, scanty and difficult to see. The nucleus comes to rest on one side of the cavity some distance removed from the transverse wall.

Gradually the cytoplasm becomes more pronounced, stains more deeply and fills the elongating chalazal end. The apex becomes somewhat expanded into a knob which, as the cell lengthens, is plunged into the mass of megaspores. These are still evident, but are now on the way to disintegration as is attested by the fact that they lose all structure and become black and opaque with haematoxylin, often making it very difficult to recognize the apical, knobbed part of the long antipodal. At the time when the basal antipodal is first cut off, there is a large mass of proteinaceous food in the place of the once archesporium, which as just stated, stains very deeply. As the embryo-sac as a whole reaches maturity, before the flower opens, the cytoplasm about the endosperm nucleus becomes abundant and dense, and the archesporial food-

mass is coördinately reduced, while the basal antipodal shows its maximum development during this period. The probe-like end, which, I believe, serves as a haustorium, at this time and somewhat later is filled with cytoplasm which appears finely reticulate, while the broad end which is adjacent to the upper part of the embryo-sac is occupied by a large vacuole. This large antipodal must, therefore, stand in an important relation between the food supply derived from the archesporium and the endosperm cell, and is probably active in the transportation of the food from the former to the latter. The megaspore mass thus forms a sort of nutritive tissue, partly analogous to that described by Dr. Balicka-Iwanowska (*l. c.*) as occurring in the region of the integument near the lower ends of the embryo-sac in the forms studied by her.

The archesporial tissue is now seen to bear a nutritive relation to the embryo-sac, which by this time has reached maturity.

THE DEFINITIVE EMBRYO-SAC

We may now pause to sum up the characters of the mature embryo-sac.

In shape it is fusiform and much attenuated at the lower end. The upper part, comprising one third or more of the entire length, contains the egg apparatus and the endosperm nucleus, and constitutes the expanded part of the embryo-sac. The fusion of the polar nuclei takes place at about the middle of this part of the embryo-sac, but at the time of fertilization the resultant nucleus comes to lie immediately against and partly surrounding the egg nucleus. The migration of the endosperm nucleus has been noticed by Mme. Balicka-Iwanowska (l. c.) in *Digitalis* and other related forms in which the embryo-sac is more or less attenuate. At the time it reaches the egg, the nucleolus has nearly three times its original diameter. Its size relative to that of the egg nucleus is shown in Pl. 2, Fig. 8a. The nucleus itself is larger than the egg nucleus, but the discrepancy in size is more striking between the nucleoli. This movement and growth of the endosperm nucleus must be interpreted physiologically; it is in all probability in some way connected with the nutrition of the egg.

The antipodals are three in number; two of these are small

and relatively inconspicuous; the third and basal, is very long, being on the average about two thirds the length of the whole embryo-sac, though it may, in exceptional cases which I have noted, attain a considerably greater length. At its expanded upper end it is separated from the upper region of the embryo-sac by a very thin transverse wall. Its lower end is somewhat knobbed, and is embedded in a mass of degenerating megaspores. The position of the nucleus of this antipodal is always lateral and about one fourth to one half the cell's length from the upper end (Pl. 2, Figs. 7–11). It is large and prominent, and evidently active. Its function has already been discussed. The fate of the antipodals will be discussed somewhat later.

DEVELOPMENT OF THE EMBRYO

After the egg is fertilized, its vacuole enlarges considerably, pushing the cytoplasmic end rather more deeply into the endosperm stuff. Immediately the endosperm nucleus commences to divide so that before the first division of the fertilized egg takes place 20 to 30 endosperm nuclei are present (Pl. 2, Fig. 10). The proembryo now grows rapidly by the successive occurrence of approximately transverse divisions. When about five cells have been formed, the proembryo becomes bent to one side and the other. This is due to the lateral enlargement of certain of the suspensor cells, as a result of which they bulge out into the endosperm which is now of some bulk. In these enlarging suspensor cells, the cytoplasm becomes vacuolated to a considerable degree. These facts and later developments indicate that these cells are concerned in the absorption of foods in solution from the endosperm, which, however, is not broken down by the enlarging suspensor cells. The cells of the end of the embryo away from the micropyle are always smaller during the earlier development of the proembryo, while they get successively larger toward the micropylar end where the basal cell tapers off acutely, giving the young proembryo something of a spindle shape (Pl. 4, Figs. 1, 2).

When the proembryo attains the number of about six cells, longitudinal divisions occur in some of the suspensor cells. The divisions sometimes occur in two planes, and the resulting elements continue to grow and bulge out further into the endosperm and

form haustorial appendages. In some cases when two longitudinal divisions have taken place in a single suspensor cell, a pair of the resulting quadrants grow out together, forming double haustoria (Pl. 4, Fig. 5). Again the haustorial cells may divide transversely; this occurs only in the region near the embryo proper.

These haustoria, for such I regard them, are at first pronouncedly vacuolated, but as the embryo ages the vacuolation disappears, and they become densely filled with cytoplasm. After the embryo proper begins its development, the basal suspensor cell elongates considerably, increasing its length by a half and becomes less vacuolated. Its micropylar end becomes crushed by the growing endosperm, which now begins to grow into the micropylar part of the thickening integument, leaving the embryo in a more central position (Pl. 4, Figs. 9, 10). Later, the basal cell and even one or two of its neighboring suspensor cells become disorganized, but the time at which this occurs is not constant, for while I was not able to find these cells in the preparations from which Figs. 5 and 6, Pl. 4, were drawn, I did find them in another specimen of such an age as the one shown in Pl. 4, Fig. 7.

After the embryo proper has differentiated itself from the suspensor, the latter may be seen to be divided clearly into two regions which differ very markedly in structure. These two regions may be termed the micropylar and embryonal. The latter is made up of half a dozen disc-shaped cells which are very much flattened longitudinally, and show no outgrowths and are not vacuolated, and they remain so during the entire embryonic history. The cells of the micropylar region, on the other hand, become larger and thus increase their absorbing surface. When they reach their maximum development the suspensor when dissected out resembles a "bunch of grapes." These outgrowths, to which we have ascribed a haustorial function, are not unlike the suspensorial haustoria (Keimträgerblasen, boyaux) described by Treub in the *Orchidaceae* and by Hofmeister* ('49) and Guignard (*l. c.*) in *Sutherlandia*, and are analogous to the "zuigblasen" occurring in the teak (*Tectona grandis*) described by Koorders ('92). The upper part of the micropylar region, as shown above, becomes less important and is finally lost by absorption, so that the embryo

* Die Entstehung des Embryo der Phanerogamen. Leipzig, 1849.

with its suspensorial haustoria, to which it is attached by the short row of disc-shaped cells, comes to lie entirely within the now large mass of endosperm (Pl. 4, Figs. 9, 10). The structures above described are probably to be regarded as an adaptation for the ready absorption of food for the rapid growth of the embryo. The shortness of the cells of the embryonal region of the suspensor favors the passage of food to the embryo. Whether or not the embryo is capable of absorbing food through its own surface is a question which I am unable to answer at this time. Koorders ('92), working on *Tectona*, found that the embryo till the completion of the "Kogelstadium" possessed cuticularized walls, thus preventing the absorption of food. If this be true of *Vaillantia* and its close relatives, we have a complete explanation of the significance of the haustoria. But even if the embryo is not cuticularized, it is not improbable that the amount of absorbing surface on the embryo proper alone is insufficient for its rapid development, and it may be that in this lies the explanation of many features in other forms not yet cleared up. For example, I have found that the basal cell in *Capsella*, figured years ago by Hanstein, and copied in almost every text-book, actually pushes its way into the adjacent tissue of the inner integument in the same manner that the embryo-sac itself, by its growth, in many cases encroaches upon the surrounding tissue. This fact indicates that the suspensor, in forms in which it reaches so pronounced a development, as in the *Cruciferae*, *Tropaeolum* and others, is of importance in absorbing nourishment, an opinion which we must credit to Meyen ('39).* I believe this action of the suspensor in the surrounding tissue to be correlated with the rapid growth of the embryo in *Capsella*. Before drawing any conclusions of this kind, however, it will be necessary to obtain many more data.

There can be little doubt that the rapid development of seeds is an important adaptive feature, and the study of structures which are correlated with this ability will be a fertile field for further study. Such haustorial structures as those found in the *Orchidaceae* may be correlated with the meagre integument which means a meagre store of food immediately at hand.

The further development of the embryo, which brings the

* Neues system der Pflanzen-Physiologie 3: 331. 1839.

cotyledons into view, is accompanied by the dissolution of a zone of endosperm surrounding the embryo. The cells become mucilaginous, and the embryo is bathed in nutrient substance. The relative increase of absorbing surface by the development of the cotyledons is accompanied by the gradual loss of the haustoria of the suspensor, of which there may be found, at the time of the ripening of the fruit, only a few of the disc-shaped cells. The last of these plays a small part in the formation of the radicle.

THE INTEGUMENT

The earlier development of the integument has already been described. Some time before complete maturity of the embryo-sac is reached the cells which form a zone (*d*, Fig. 1, Pl. 3) about the attachment of the funicle to the ovule become large and rounded (Pl. 3, Fig. 1, *d*) and their contents become strongly vacuolated. These cells contain a good deal of starch at quite an early condition of the ovule, and when the accumulation of starch in the integument commences, the process has its beginning here. At the end of the vascular bundle when it reaches this zone of enlarged cells, is found a mass of cells which gives the bundle a club-shaped appearance in longitudinal section. These cells, like those of the leptome of the bundle, are rich in contents, and form a center for the distribution of food, which is received by the large-celled zone above referred to, the function of which appears to be the preparation of food and the regulation and distribution of the supply to the meristematic zone. The latter is made up of smaller cells (Figs. 1*b*, 1*c*, Pl. 3), in which, after fertilization multiplication begins. Their dividing walls are periclinal, and there results a rapid thickening of the integument, with a corresponding increase of the ovary wall, accompanied by secondary changes leading to the formation of a schizocarp. Within the meristematic zone the integumental tissue shows signs of disintegration, and this process appears to be as rapid and complete in the tissue surrounding the basal antipodal as in that about the endosperm region. We may notice in this connection that the mass of disintegrated megaspores has after fertilization and before the first division of the proembryo almost disappeared (Pl. 2, Fig. 9; Pl. 3, Fig. 3) and the antipodal cells are difficult to

see. In some genera they persist for some time, and vestiges may be seen after a large mass of endosperm has been formed. After the megaspore mass is absorbed, the basal antipodal appears to have no further function.

When the embryo starts to develop a small amount of starch is found in the integument, principally in those cells above referred to which form a zone between the funicle and the meristem of the integument. A very few granules are also to be found in the cells immediately about the embryo-sac. As the seed approaches maturity the starch accumulates first in the peripheral cells until all those cells of the integument which remain are replete.

THE GROWTH OF THE ENDOSPERM

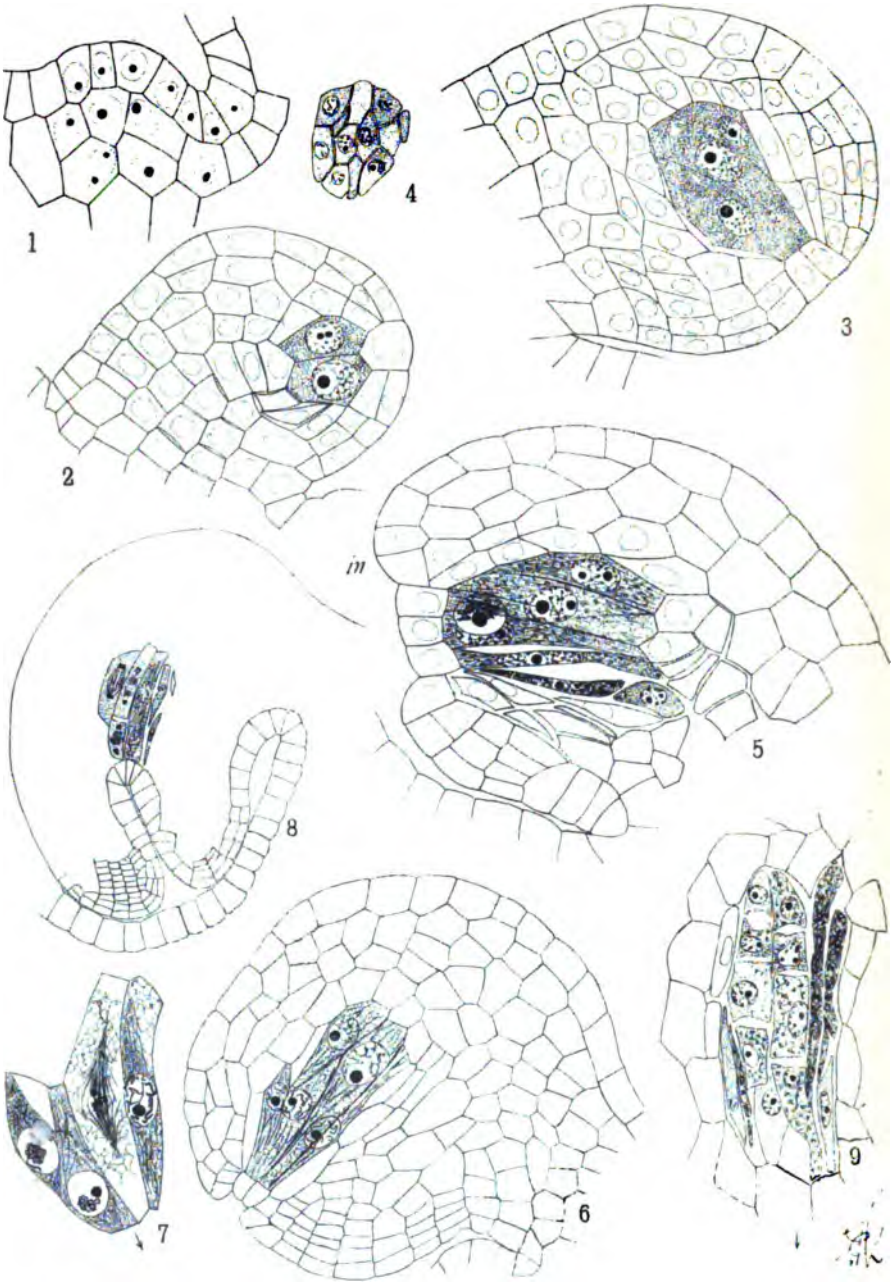
During the first division of the endosperm nucleus the endosperm enlarges, becoming rounded, and encroaches upon the adjacent tissue of the integument, the cells of which become flattened and give way. At first, separating walls between the cells are not formed. The nuclei are not parietal, nor do they ever become so. The endosperm mass is always solid. A little later the parietal cells become much more densely filled with cytoplasm and stain more deeply (Pl. 3, Figs. 2*b*, 2*c*). This is especially true of those cells on the side of the endosperm mass facing the longitudinal axis of the ovary, which are the earliest to become dense. It is on this side that the thickness of the integument is the greatest and where the food is most abundant. After the endosperm approaches its limit of growth, these are the last of the peripheral cells to lose their dense character. The inner cells of the endosperm are strongly vacuolated, the vacuolation becoming more pronounced towards the center, where the cells ultimately break down and leave a cavity within which lies the now rapidly maturing embryo. The peripheral cells are digestive, I believe, and absorptive, for the integuments break down in advance of the growth of the endosperm, and the cell walls of the disorganized cells become thickened. These thickened walls stain readily and deeply with safranin, while the walls of the normal cells show much less affinity for that stain.

As the endosperm ages it becomes concave on its inner face, and dipping into the concavity is a mass of integument which

remains undigested at the maturing of the fruit. (In Pl. 3, Fig. 2.) This mass is continuous with a thin layer of integument two cells in thickness, which surrounds the endosperm. The latter does not, contrary to the opinion of Hofmeister, break through the integument, so that the envelopes of the mature fruit consist of the wall of the ovary lined by an integument (Pl. 3, Figs. 2, 2*a*) two cells thick and loaded with starch. The endosperm cells up to a time when the embryo is large and approaching maturity, have thin walls. Starch accumulates more and more till the cells are gorged. Just before the complete maturity, however, the walls thicken so that in the mature seeds the principal foods stored in the endosperm are reserve cellulose* and starch.

The central part of the endosperm is, up to the completion of the sphere stage of the embryo, continuous, so that the embryo lies in direct contact with the endosperm cells. When, however, the cotyledons begin to appear, the endosperm immediately surrounding the embryo breaks down, so that the embryo comes to lie freely in a cavity which is filled with fluid materials. The behavior of the endosperm in this regard, as also the integument during the advance of the endosperm upon it, indicates the presence of digestive agent secreted by the embryo on one hand and by the endosperm on the other.

* The term 'reserve cellulose' is used here provisionally. The exact nature of the substance in the *Galieae* is, I believe, not yet determined.



VAILLANTIA HISPIDA

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Explanation of Plate I

Fig. 1. The fundament of the nucellus, × 670.

Fig. 2. The archesporial cells, of which only two are seen in the section, have begun to be differentiated. They apparently underlie only one epidermal capping cell.

Fig. 3. The archesporium more strongly developed. The periclinal divisions about the capping epidermal cells mark the beginning of the growth of the integument.

Fig. 4. Transverse section through archesporium; it is composed in this instance of twelve cells, × 670.

Fig. 5. Integument is well marked; maximal elongation of archesporial cells; disintegration of some of the inner cells has begun, × 670.

Fig. 6. Somewhat older condition of the ovule in which the archesporial cells are preparing for division; micropylar canal is begun, × 472.

Fig. 7. First division of the archesporial cells. The arrow is directed toward the position of the micropyle, × 670.

Fig. 8. A still more advanced condition of the ovule in which the micropylar canal is deep. The second division is taking place in some of the archesporial cells, × 315.

Fig. 9. Definitive megaspore. On the right one sees imperfectly formed and degenerating megaspores, × 670.

Explanation of Plate 2

Fig. 1. The embryo-sac mother cell has migrated down the micropylar canal, having passed to one side of the nucellar cells which cap the archesporium. The remaining megaspores are beginning to disintegrate, × 670.

Fig. 2. Embryo-sac with four nuclei, × 670.

Fig. 3. Embryo-sac with eight nuclei. One of the antipodals is cut off from the remaining seven nuclei by a transverse wall, × 670.

Fig. 4. Egg apparatus and antipodals definite. Approach of polar nuclei, × 472.

Fig. 5. Fusion of polar nuclei completed. The position of endosperm nucleus is near the middle of the sac, × 472.

Figs. 6 and 7. Approach of endosperm nucleus toward the egg, and their concomitant increase in size, × 472.

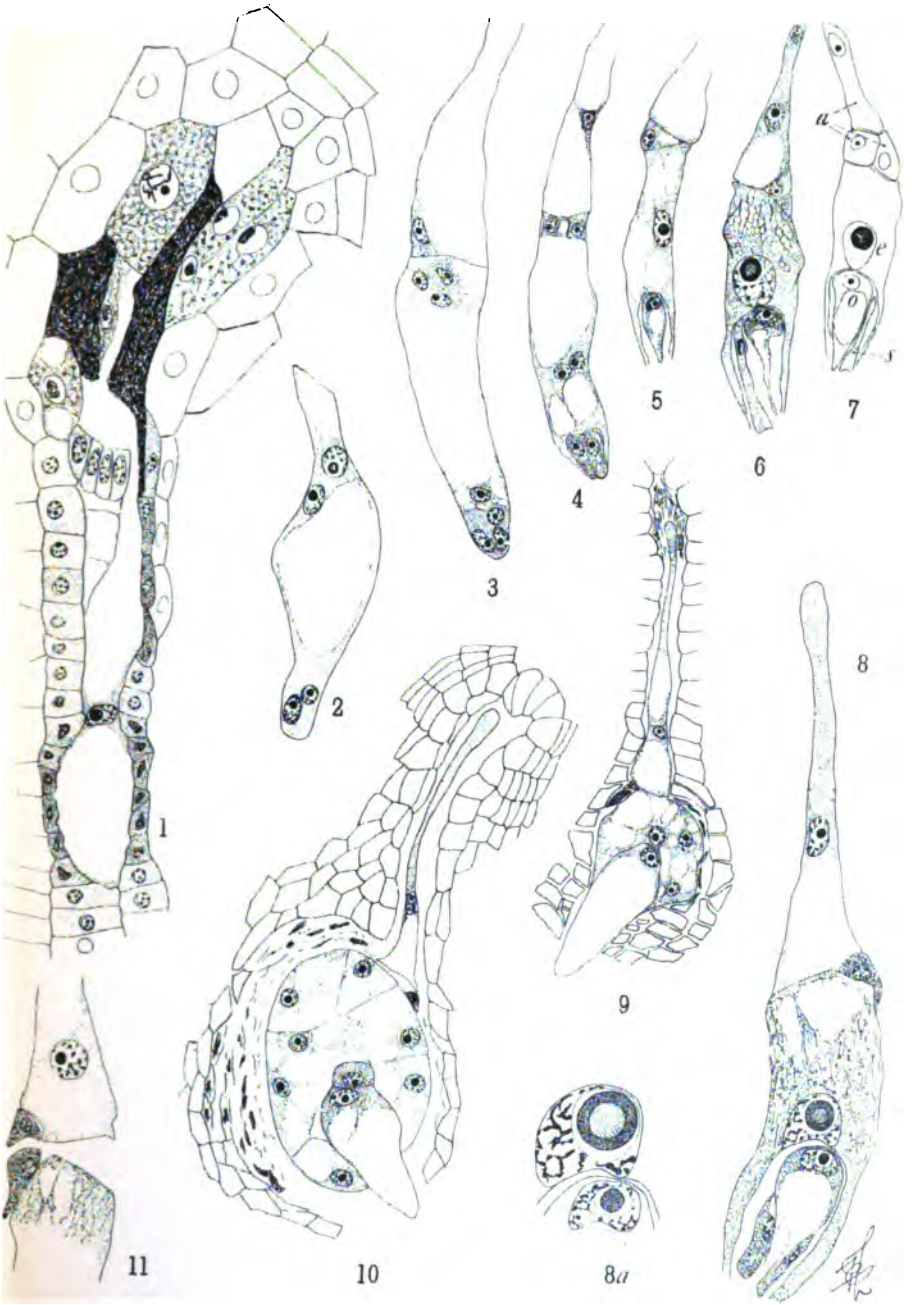
Fig. 8. Mature embryo-sac. The endosperm nucleus is now applied to the egg, × 670.

Fig. 8a. Egg and endosperm nuclei of the same, × 1350.

Fig. 9. After fertilization; embryo is still one-celled; several endosperm nuclei are now present; the disintegrated megaspores are now nearly absorbed; the endosperm begins to encroach on the integument, × 315.

Fig. 10. Embryo two-celled. The endosperm, in which walls begin to appear, encroaches further upon the integument, × 315.

Fig. 11. Three antipodal cells, × 670.



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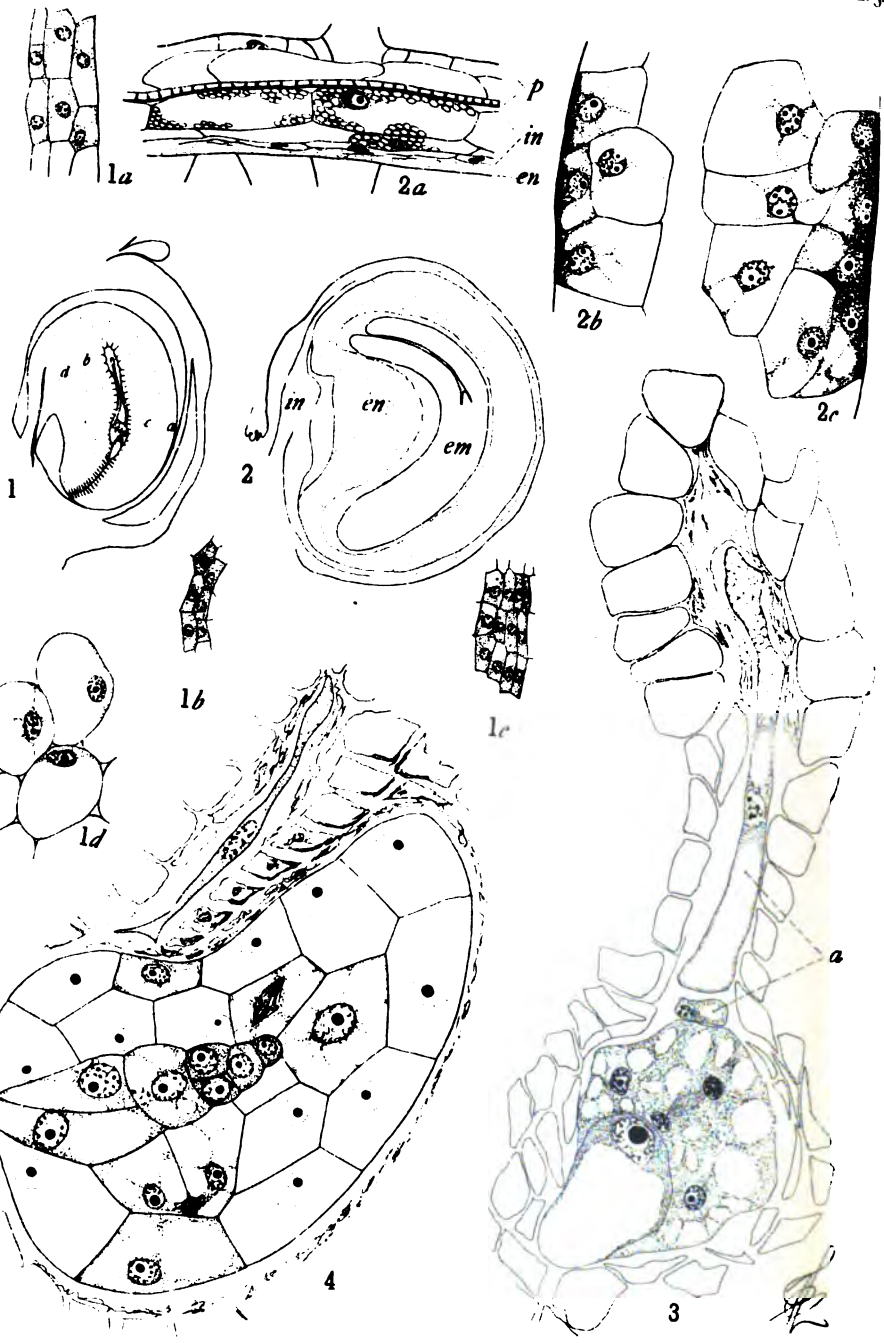

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Explanation of Plate 3

Fig. 1. Ovule just after fertilization showing areas made up of cells of different character. (*a*) Zone of cells dividing mostly by periclinal walls (see Fig. 1*a*). (*b*, *c*) Zone of rapidly multiplying cells (see Fig. 1*b*, 1*c*) forming a meristem completely surrounding the internal mass including the embryo-sac. (*d*) Mass of cells lying between the funicle and the meristem, made up of large cells (see Fig. 1*d*) containing vacuolated cytoplasm and starch grains, × 75.

Figs. 1*a*, *b*, *c* and *d*, × 670.

Fig. 2. Longitudinal section through mature fruit, in. integument, en. endosperm, em. embryo. The pericarp is seen as a thin layer without the integument.

Fig. 2*a*. Envelopes of mature fruit in detail. *p*. pericarp, *in*. integument, *en*. endosperm. The cells of the integument are still supplied with much starch, × 220.

Fig. 2*b*. Cells from periphery of endosperm on convex or dorsal aspect, × 472.

Fig. 2*c*. Cells from periphery of endosperm on concave or ventral aspect, × 472.

Fig. 3. After fertilization. The basal antipodal has its haustorial end embedded in a mass of refractive substance which results from the disintegrated megaspores. Embryo still one-celled, × 670.

Fig. 4. Young embryo lying in the endosperm. The latter by its growth pushes past the long antipodal into the integumental tissue as toward *c*, Fig. 1, × 472.

Explanation of Plate 4

Fig. 1. Proembryo of 5 cells, × 670.

Fig. 2. } × 472
3. }
4. }

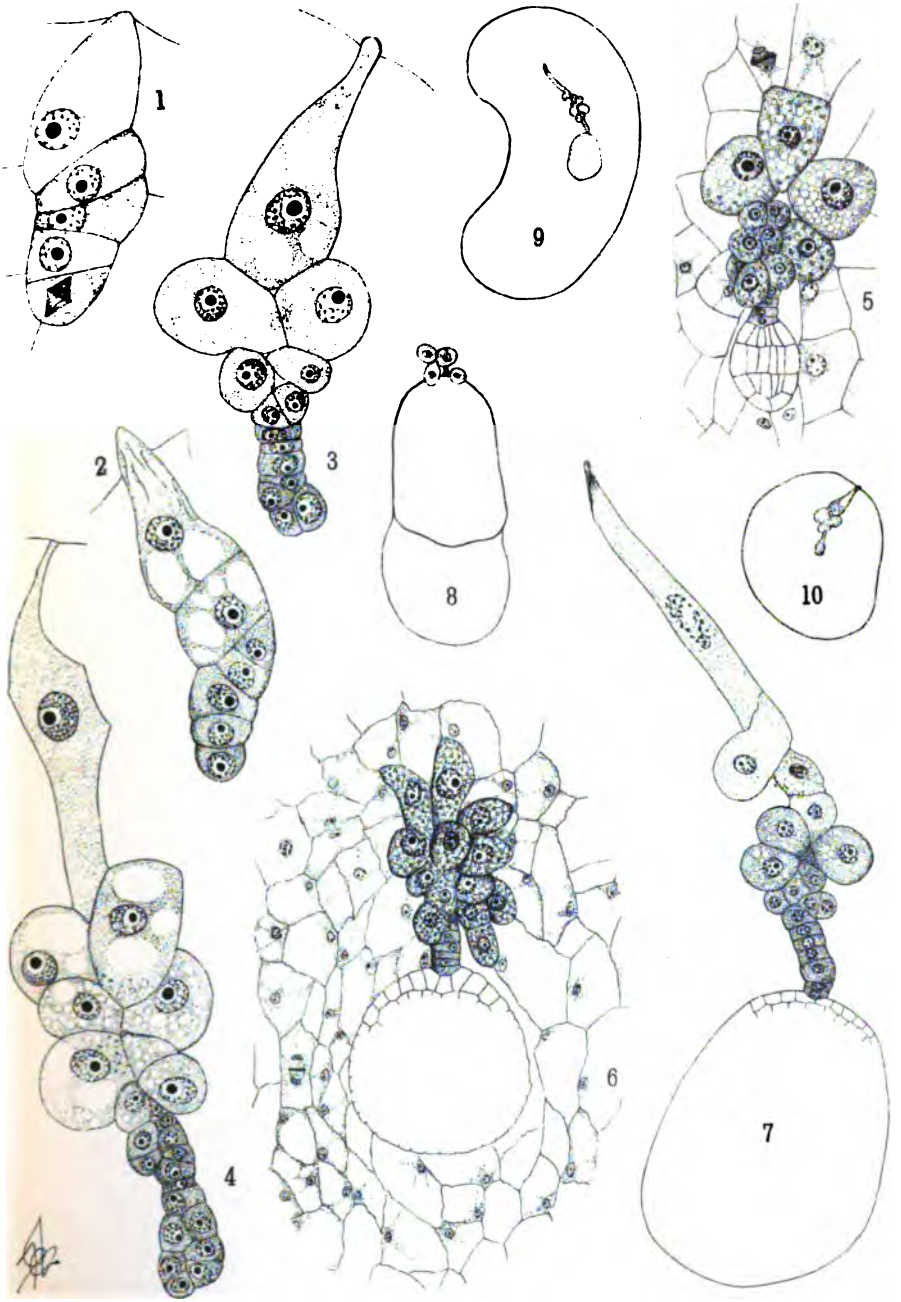
5. } × 315
6. }
7. }

8. × 75

Successively older stages of the embryo.

9. × 50 } Embryo, drawn on larger scale in Fig. 7, lying in the endosperm.
10. × 75 } " " " " " " " " 3, " " " " "

A comparison of these last two figures shows the position taken by the proembryo as a result of the growth of the endosperm at the micropylar region.



VAILLANTIA HISPIDA

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FURTHER DESCRIPTION OF GENERA

Callipeltis cucullaria

The genus *Callipeltis* embraces three species indigenous to the Mediterranean region. In general habit they resemble closely the plants of the genus *Galium*, from which, however, they differ in their smaller size. *Callipeltis cucullaria*, the species studied, was collected in growing condition in the Botanical Garden at Berlin.

The Nucelli

The nucelli, two in number, arise as in *Vaillantia*, on either side the center of the floor of the ovary. Nor is their course of development different from that already described for that genus, excepting in matters of only minor moment, and these are to be found in the total number of cells in the nucellus, the greater relative amount of archesporial tissue, and in the shape of the definitive ovule.

The archesporium, the cells of which are more numerous than in *Vaillantia*, is evident when the nucellus is quite small (*pl. 5, fig. 1*). The epidermal capping cells remain without any further growth, while immediately around the area occupied by them, the integument grows out, as is made evident by the numerous periclinal divisions to be seen at this stage (*pl. 5, figs. 2 and 3*). By subsequent growth, the integument is developed so as to shut in a long micropylar canal (*pl. 5, fig. 4*). As the ovule attains its definitive form, the absence of the large special cells seen in the ovule of *Vaillantia* is noticed, and the sporogenous cells of the archesporium divide. The division into four megaspores is by no means complete for each cell. Some of them, the more centrally placed, divide more rapidly and completely, while the more peripheral lag behind and sometimes fail of division, or perhaps divide but once, and so a heterogeneous mass results, out of which the megaspore which develops into the embryo-sac makes its way into the micropylar canal. In such

a mixture of cells it is not easy to distinguish this cell, especially as it often happens that several pass through the initial stages of migration, and the result is very confusing. I have, however, with reasonable certainty, been able to pick out the most active cell, as in *figs. 4 and 5*. The embryo-sac cell, so far as determined, may arise out of any of the megaspores, so that we may regard these for the greater part as physiologically equivalent. The appearances presented by the archesporium at this time match closely those seen in *Alchemilla* as described by Murbeck.* Tapetal cells are not formed.

No starch is seen in the integument until the migration of the megaspore, when a slight accumulation occurs, evenly distributed throughout the whole. During the maturing of the embryo-sac, the amount of starch increases in a zone surrounding it. As the endosperm starts to grow, zonal accumulation disappears and a general distribution is again seen which becomes gradually more pronounced in the peripheral parts.

THE DEVELOPMENT OF THE EMBRYO-SAC

One of the megaspores which have developed as described above commences to enlarge and to migrate along the micropylar canal. This takes place when the ovule is well developed and has taken on its mature form. *Pl. 5, fig. 4*, shows these conditions just previous to the migration of the megaspores. It not infrequently happens in this species that two or even three megaspores commence to migrate at the same time and take paths which are nearly parallel. In such cases a good deal of confusion arises, which makes it difficult to interpret properly the preparations showing this condition. The remaining megaspores retain their character for some time, some degenerating more rapidly than others, and the resulting mass adds not a little to the difficulty of making out clearly what one sees. Occasionally two of the migrating megaspores germinate, although in no cases which I have observed has development passed beyond the four-celled stage (*pl. 5, fig. 8*) in any but the more advanced and normal one, which is set apart as the fundament of the functional embryo-sac.

* Murbeck, Sv. Parthenogenetische Embryobildung in der Gattung *Alchemilla*. Acta Reg. Soc. Physiogr. Lund, 11 : 1–47. 1901.

More than one embryo-sac may sometimes reach perfect development, thus supplying the conditions for false polyembryony. This, however, has not been observed.

The movement of the megaspore down the micropylar canal is accompanied by histolysis of the endodermis, the cells of which degenerate and collapse. The contents of the cells are disorganized and become deeply staining. It is to be noted that the nucleus is preceded in its course by a part of the cytoplasm, while the nucleus itself travels unusually near, or along the side of the cavity formed and some little distance back from its apex (*pl. 5, fig. 6*). The amount of cytoplasm is now not great, nor does it increase markedly in amount until the complement of embryo-sac nuclei is reached. The cells of the egg apparatus, as soon as they are cut off, become rapidly different in character from the rest in attaining greater density. Their final character is reached at about the time of fusion of the polar nuclei or somewhat later. The synergids then are vacuolated at their free ends, while the egg-cell has a vacuole at its narrow basal end. The fusion of the polar nuclei occurs near the middle of the endosperm cavity (*pl. 5, fig. 8*) and is followed by a movement of the resultant nucleus toward the egg-cell with which it lies in contact till its first division. Meanwhile the cytoplasm loses its vacuolated character and becomes more dense and gorged with food material, consisting, in large part, of starch. The whole endosperm-cell becomes more rounded also.

THE ANTIPODAL CELLS

When the fusion of the polar nuclei is taking place the antipodal nuclei have arranged themselves in their definitive positions, two of them close together, each with its proper mass of cytoplasm which is thin and vacuolated, and the third some distance away in the narrowing end of the somewhat irregular cavity formed by the megaspore in its migration (*pl. 5, fig. 9*). The cytoplasm of this latter antipodal cell is at first extremely scanty, so much so that it cannot be detected with a high power except near the nucleus. The two small antipodals secrete cell walls and remain in a normal condition for some time during the development of the embryo. Their cytoplasm becomes more dense from the time they are first

cut off, and numerous starch grains may then be seen. The long antipodal which occupies about three-fourths of the length of the entire embryo-sac takes on a definite club shape at its free extremity which reaches quite to the end of the megaspore cavity, and is finely granular, though not so densely filled with protoplasm as are the others. A large vacuole appears constantly at the thick end which abuts against the small antipodals. The vacuole extends as far as the nucleus. The interior of the narrow upper part is also occupied by a vacuole, though this is less evident in sections on account of the slender character of this region of the cell. A normal appearance is presented by this cell as by the other two until the proembryo has reached an eight- or ten-celled stage or even older (*pl. 6, fig. 5*), and an application of the iodine test demonstrates that at such a time the small antipodals are gorged with starch while the other shows a similar starch content at its thick end. The haustorial end stains deep yellow and is free from starch. No trace of the deeply staining products of disintegrated megaspores may be seen after the second or third division of the endosperm nuclei, though this is, of course, a somewhat variable matter. Disintegration of the antipodals sets in with the rapid extension of the endosperm, and they are finally lost to view.

ENDOSPERM AND INTEGUMENT

Soon after fertilization the endosperm nucleus divides. This division is followed by several others, probably five or six, before any walls are laid down. Its starch content is drawn upon during these divisions, so that at the time the cell walls are laid down, only a very little may be found or none at all. The proembryo remains unicellular till about the third or fourth division of the endosperm nuclei occurs. The growth of the endosperm is accompanied by destruction of the integument. The peripheral endosperm cells become less vacuolated, the greatest density of contents being found in those cells of the endosperm which lie towards the raphe, *i. e.*, the peripheral cells are most active where the largest amount of food is available. The accumulation of starch is gradual at first and is localized in the chalazal end of the endosperm. Later all the cells become gorged with starch, so that at the time the cotyledons appear, all the cells are well supplied with

the exception of those which occupy the middle portion of the endosperm and the layer of absorbing cells next the raphe. The endosperm continues however to grow, and ceases only when there is left of the integument only a single layer of cells separating the endosperm from the pericarp. The limit of growth in extent being reached, the cells commence to secrete reserve cellulose. Their lumina, by reason of the accumulating cellulose, become more contracted and rounded in form. The increase of cellulose is accompanied by an evident reduction of the starch content, though a plentiful supply is present at the maturity of the seed.

The immediate supply of food necessary for the endosperm is to be found in the integument, of which the starch content is gradually increased as it reaches its maximum size. When the seed is ripe, a single layer of integumental cells only is left, excepting an island of tissue underlying the termination of the vascular tissue of the funicle. The endosperm is thus a concavo-convex mass, surrounded by an integumental membrane, this, in turn, being closely invested by the pericarp four cells in thickness (*pl. 6, fig. 12*). A considerable amount of starch is found in all the cells of the integument, particularly in the chalazal island.

DEVELOPMENT OF THE EMBRYO

As already pointed out, the embryo remains unicellular till the endosperm nuclei have reached the number of eight to sixteen, when it begins to develop rapidly, one transverse division following another until the embryo is composed of a cell row of ten or a dozen cells (*pl. 6, fig. 6*). The largest of these are in the suspensor. The terminal cell, the fundament of the embryo proper, is the smallest. The suspensor cells bulge out more or less. A portion of the suspensor may be composed of two rows of cells (*pl. 6, fig. 9*), though, whether this is due to transverse division or to displacement by longitudinal pressure, I cannot say. Probably, however, the latter. The arrangement and number of cells in the suspensor is by no means constant, so that it is a matter of physiological significance alone. By further growth, the bulging suspensor cells extend themselves, so as to lie between the endosperm cells, but do not cause any destruction. They are filled with cytoplasm, and have large active nuclei. The development

of haustorial cells by the embryo in *Callipeltis* is not so great as in *Vaillantia*, either in point of number or size. With the development of the embryo proper and of the endosperm, the basal cell elongates, allowing the embryo to take a more central position in the endosperm. The haustorial portion is then near to the embryo. The basal cell is finally crushed between the cells of the endosperm, the haustorial portion becomes absorbed, so that only a single cell is left as a portion of the root cap of the embryo.

The development of the embryo is briefly as follows: After transverse division has ceased, the terminal-cell divides longitudinally once, then a second time. The second cell from the end follows suit, then the third and finally the fourth. Meanwhile the first three tiers of cells are giving rise to dermatogen, then to plerome in the fashion described by many authors for numerous dicotyledons. The fourth tier of cells which apparently never exceed four in number, remain so and may be recognized in the definitive embryo as a small protuberance at the top of the root cap.

A great deal of variation takes place, but the plan just set forth is followed in general and the ultimate product is the same.

Sherardia arvensis

This plant, the only species of the genus, is a small upright annual having the whorled foliage of the Galieae with small heads of several flowers with rose colored tubular corollas. It is distributed in Western Asia, Europe and North Africa. The material for study was obtained in cultivation in Germany and in New York.

The history and character of the nucelli, integument and megaspore mother-cells call for no special treatment. No evidence has been obtained pointing to differences in the division of the megaspore mother-cells, or in the selection of a given megaspore to become the embryo-sac. It thus appears that the megaspores are of potentially equivalent value. During migration down the micropylar canal the three serial divisions of the embryo-sac nuclei take place and finally a definitive embryo-sac is formed which differs somewhat from those hitherto described in form and

proportion (*pl. 6, fig. 15*). The two small antipodals are concavo-convex, and are set upon the endosperm cell as a cap. They are densely filled with food materials. The third antipodal is longer relatively than in either *Vaillantia* or *Callipeltis*, and is scantily supplied with cytoplasm. The distal end is formed into a club-shaped swelling, and is buried in the mass of disintegrated megaspores. The swollen end is filled with a tenuous and finally granular cytoplasm.

The endosperm nucleus lies in the definitive embryo-sac against the egg, into which position it has moved from a distant position where fusion of the polar nuclei takes place (*pl. 6, figs. 15, 16, 17*).

The development of the embryo proceeds by the formation of transverse walls, until about a dozen cells in linear arrangement have been laid down. All but the terminal cell form then the suspensor in which two distinct regions are to be recognized. The micropylar region is composed of larger vacuolated cells, which grow out laterally into the endosperm forcing their way between the cells. The nucleus lies in the concavity of the outgrowing haustoria just as is known to occur in young root hairs (*pl. 6, fig. 19*). The proximal portion of the suspensor is composed of very short disc-shaped cells, which, while the embryo is young, retain that form. As the embryo becomes older, the more distal of these elongate, and some grow out into haustoria. When the endosperm has reached its maximum size the laying down of reserve cellulose begins in the peripheral cells first, and these cells become unfavorable for the absorption of food by the suspensorial haustoria. That portion of the suspensor, therefore, which comes to lie in the region of cellulose formation degenerates *pari passu* with the thickening of the cellulose layer. The function of absorption thus given up by the more distal part of the suspensor is then taken up by the more newly formed haustoria. The suspensor becomes loaded with food which is gradually passed on to the embryo (*pl. 6, fig. 21*).

In the development of the embryo proper there is correspondence with the process as described for *Callipeltis*. One feature appears somewhat different, namely, that the longitudinal division of the terminal cell is followed by transverse division of its quad-

rants, so that it appears as if the terminal five cells had gone to form the embryo proper instead of four.

The mature ovule consists of a mass of endosperm with cellulose as the chief reserve food, and one layer of integumental cells still intact. The whole is closely invested by the pericarp.

The endosperm absorbs the integument till but one or two cell layers are left, these forming a membranous lining of the pericarp.

Galium

(PLATE 7)

The species of *Galium* which have been studied are the following: *G. Aparine*, *recurvum*, *pilosum*, *Mollugo*, *verum*, *triflorum*, *tinctorum*, and *Parisiense*. As the species of this genus are very similar with regard to the characters which we are considering, it is not deemed necessary to treat them separately.

The origin of the nucelli is in all respects as in the forms already described, and the same may be said of the number of cells in the archesporium (*figs. 1, 2 and 3*), their division into megaspores by two successive divisions (*fig. 4*), and the subsequent enlargement of one of these to act as the embryo-sac cell. In occasional instances two such cells derived from different megaspores may enlarge and when germination takes place, two more or less completely formed embryo-sacs result (*fig. 11*). In one case three such were found, although here the third embryo-sac was very abnormal in appearance. The nucellar epidermal capping cells remain intact until the megaspores are fully formed, but suffer histolysis at about the time the migration of the embryo-sac mother-cell commences (*fig. 4*). The histolysis of the endodermis then follows, as the enlarged megaspore moves forward along the micropylar canal.

The condition of the definitive embryo-sac is reached in the usual manner. A two-celled condition is shown in *fig. 6*. The chief interest in this connection attaches to the form the embryo-sac takes in the various species of the genus under consideration. The various degrees of curvature seen in different species is, no doubt, due to the form of the ovule. The more strictly anatropous the ovule, the straighter the embryo-sac. In *Galium tinctorum* in which the ovule approaches the campylotrous condition, the embryo-sac is bent into an arc of ninety degrees (*fig. 10*). In other

respects save in three particulars the characters of the embryo-sac are uniform namely, in the form of the endosperm cell, the shape and disposition of the antipodals and the amount of the food content. In certain species, *e. g.*, *G. Mollugo*, and *G. Parisiense*, the endosperm cell is almost spherical while in others it is oval. In *G. tinctorum* this cell is markedly constricted about midway its length and this appears to be the normal condition (*fig. 10*). In this plant also, the food content of the endosperm cell is evidently greater, and is composed for the most part of starch. The starch grains are indeed so crowded that the nucleus is very much distorted by compression (*fig. 10*). Finally the antipodal cells may take two different arrangements. They may be placed tandem fashion as in *G. triflorum* (*fig. 7*) and *G. Mollugo* (*fig. 11*), or the two small antipodals may lie in the same transverse plane as occurs in *G. Aparine* (*fig. 8*) and *G. Parisiense* (*fig. 12*), and some others. A modification of this latter mode of arrangement is to be found in *G. tinctorum* (*fig. 10*), in which plant these cells become rounded and are placed obliquely with reference to the longitudinal axis of the embryo-sac. These cells are at the same time densely filled with starch, a good deal of which material is also to be found in the long antipodal cell.

The haustorial antipodal cell reaches, in this genus, its greatest relative length, as is illustrated by our *fig. 9* (*G. triflorum*), which shows an ovule in longitudinal section, with an embryo-sac just before fertilization.

The development of the embryo and endosperm in their earlier stages presents no differences of special note. Considerable variation is shown in the development of the suspensor in the different species. In *G. Parisiense*, for example, there is but a small haustorial apparatus formed, while the suspensor of this plant is remarkable for the unusual elongation of the basal cell (*fig. 13*). Of the species studied, the greatest development of the suspensor is reached in *G. Mollugo* (*fig. 15*).

The endosperm arises by division of the endosperm nucleus in all directions, at first without the formation of cell walls. Soon, however, these commence to form before, indeed, the suspensor produces haustoria. The histolytic changes in the integument, which take place relatively slowly at first, proceed a little later

very rapidly, and, as indicated in *fig. 14*, the histolysis is not confined to the immediate vicinity of the endosperm. In the same figure we may note the antipodal cells to be still present, but they are in a dead condition, and it would not appear that they are in any way active agents in the action described, but rather that the enzyme which we may believe is secreted by the endosperm more readily passes along the course of the antipodal apparatus and is thus distributed to a distance from the endosperm.

That the behavior of the integument as the endosperm grows is indeed the result of the action of an enzyme, we have evidence in the case shown in *fig. 15*, where the cell-walls of the cells lining the micropyle remain unaffected, although the surrounding tissue has been totally destroyed.

It is to be noted also that the endosperm nucleus takes its position against the egg cell, although this does not appear to be the case in *G. tinctorum*. This may be due to the interference of the large and numerous starch grains which crowd the cell and would very naturally interfere with the movements of the endosperm nucleus (*fig. 10*).

The food mass derived from the disintegrating megaspores becomes exhausted at the maturity of the embryo-sac or soon after and no trace of this may be seen soon after fertilization. At this time, too, the fertilized egg loses its vacuole by the increase of the cytoplasm, and the synergids at the same time disintegrate.

The course of development of the embryo is, in the early stages, like that in the others previously described.

Asperula

(PLATES 8 AND 9)

Of this genus the following five species have been studied: *A. azurea*, *galioides*, *montana*, *setosa*, and *tinctoria*.

The development of the ovule and the appearances presented by the archesporium in the genus *Asperula* do not differ in general from the other *Galieae*. They present, nevertheless, some striking points of contrast, especially when compared with *Cruciancllla*.

The early stages of development of the ovule may be passed over without further remark. When the definitive condition of the archesporium has been attained, the further development of

the ovule, especially of the integument, is such that the upper part of the sporogenous tissue becomes compressed so that the individual cells become displaced and distorted to such a degree that the whole appears almost abnormal. This appearance is accentuated during and after the division of the mother-cells, which, it would seem, is by no means as regular as in *Cruciancl1a.* This irregularity is most striking in *Asperula montana*, in the ovule of which plant the compression appears to be greatest on the micropylar part of the archesporium. This condition is obviously the cause also of certain curious abnormalities in the behavior of the embryo-sac to be described shortly. The irregularities in the behavior of the archesporial tissue consist in the differences in rapidity with which tetrad formation takes place, in the partial or total suppression of tetrad formation in a greater proportion of the megaspores, in the early destruction, by pressure, of some of the cells, and finally are such that the accurate observation of the behavior of individual cells is rendered almost impossible.

That tetrad formation takes place normally, however, is quite sure, from the fact that, in spite of the confusion, rows of four cells each are repeatedly found. The megaspores, sister to the functional embryo-sac cell, persist in apparently normal condition for a period at least equal to that occupied by the development of the embryo-sac, and occupy, forasmuch as they do not secrete cell walls, the same cavity as the embryo-sac. It sometimes happens, too, that they have quite the appearance of the antipodal cells, so that it becomes difficult to distinguish between them.

After the functional embryo-sac cell has started to migrate (*pl. 8, fig. 2*), some of the other megaspores persist, while others degenerate. Some, further, secrete cell walls, and undergo changes which indicate that they are passing through early stages of embryo-sac development. One such cell is shown in the upper right-hand part of the figure.

It seems equally certain that the tendency is for the upper of the tetrads to become the embryo-sac. The pressure already referred to, however, modifies the ordinary mode of procedure, so that not only may some other of the megaspores rather than the upper become the embryo-sac, but it may also be forced to develop in quite the wrong direction. This is the case in *Asperula mon-*

tana, in which a completely developed embryo-sac is frequently to be found in the chalazal part of the ovule, or even in the funicle. *Text figs. 1 and 2* illustrate two such instances. In *fig. 1* two

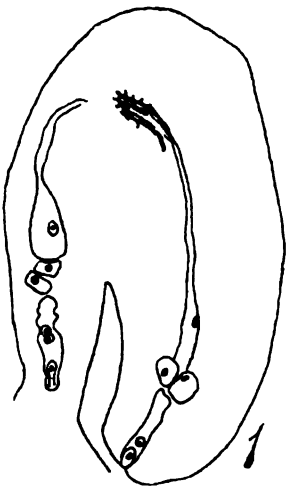

FIG. 1. Ovule with a second embryo-sac lying in the funicle.

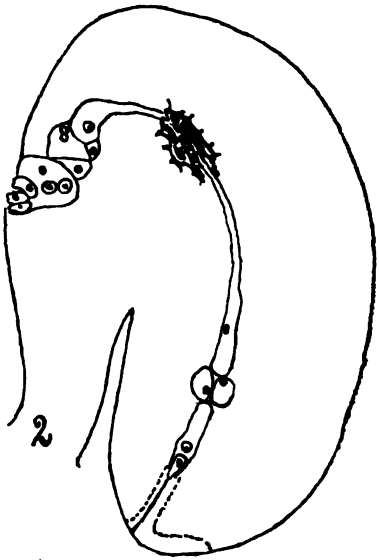

FIG. 2. Ovule with three embryo-sacs, two in the funicle and one in the usual position. The dotted line indicates the frequent protruding position of the embryo-sac.

embryo-sacs are seen; one in the normal position, *i. e.*, in the micropylar canal, and one lying parallel to it, but in the funicle. Both are completely developed. In *text fig. 2* three embryo-sacs may be seen; the one normal in position, and the two others lying against each other, in the funicle, and considerably distorted. The egg poles of these two embryo-sacs are placed against the pericarp; that is to say, the embryo-sacs have grown to the surface of the ovule. In *text fig. 3* the egg apparatus and polar nuclei of one of these abnormally placed embryo-sacs may be seen to be quite normal except for a small amount of distortion. Whether the egg of such abnormally placed embryo-sacs is ever fertilized is doubtful, and no case has been observed. This plant has flowers which show a peculiar form of dimorphism caused by the abortion of the ovules in a large percentage of cases.

Only relatively very few ovaries with normal ovules therefore are to be found, and from these only few seeds were produced under the cultural conditions at Bonn, where the material was collected. In view of these facts, therefore, the failure to observe fertilization in the abnormally placed embryo-sacs is not surprising. On the other hand, there are grounds for expectation that the behavior of the pollen tubes is such as to favor such an occurrence.

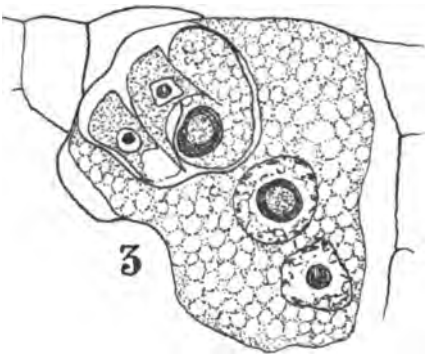

FIG. 3. Part of embryo-sac occurring in the funicle showing egg apparatus.

Further peculiarities occur in the behavior of the normally placed embryo-sac in *Asperula montana*, in that its growth continues often until the egg end projects beyond the mouth of the

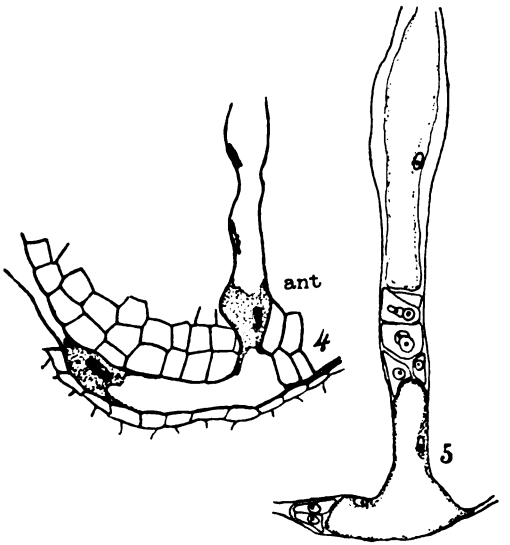

FIG. 4. Protruding embryo-sac with two nuclei in mitosis. *Ant.*, Antipodal nucleus.

FIG. 5. Protruding embryo-sac with at least seven antipodal nuclei. Polar nuclei not yet fused.

micropyle and comes to lie between the integument and the pericarp. In *text fig. 2* the dotted line indicates in a schematic way the position taken by the embryo-sac under these circumstances, and *text figs. 4 and 5* show two such embryo-sacs in detail. It is to be noted that the egg apparatus under these circumstances is always directed away from the funicle. In cases in which fertilization takes place, the egg elongates before division, and the embryo thus comes to lie within the ovule (*text fig. 6*). *Fig. 7* serves as an example, although here the egg apparatus is not as far away from the micropyle as in many other cases. The habit of the embryo of producing a long slender stalk before division is constant, and may be seen even where the embryo-sac does not protrude from the micropyle, where, namely, the embryo-sac takes the same position as in the other *Galieae* (*text fig. 7*). What the behavior of the pollen tube in this plant may be cannot be said, as no favorable material has so far been found. A study of this point cannot fail to be of interest.

FIG. 6. One-celled embryo formed in a protruding embryo-sac.

FIG. 7. One-celled embryo in embryo-sac occurring in the more usual position.

The migration of supernumerary embryo-sacs into the funicle as above described is of special interest as it bears on the question of the guidance of the embryo-sac in its movements.

Under ordinary circumstances the embryo-sac cell migrates down the micropylar canal, breaking through the thin cap o nucellar tissue. Where, however, the pressure of the integument is great enough the normal movements of the embryo-sac nucleus are prohibited, and the embryo-sac makes an irregular growth in any direction, and reaches no definite point. We may, therefore, conclude that the guidance of the embryo-sac into the micropylar canal is mechanical.

The other species of *Asperula* studied show in general the same disturbances in the archesporium due to pressure as in *Asperula montana*, though not to the same degree. This is indicated by the fact that no exception to the normal position of the

embryo-sac has been seen, although similar appearances in the archesporial tissue are there.

The only other point in connection with the embryo-sac calling for special mention is the behavior of the antipodal cells. These are by no means constant in number, and may vary even in the same species, as far as observed, from three to seven. The most typical condition is shown in *pl. 8, fig. 3*, for *Asperula azurea*, and in *pl. 9, figs. 1 and 2*, for *Asperula montana*. The long antipodal has the usual appearance corresponding as it does to the homologous cell in the other *Galieae*. The other two, however, are here very much enlarged and each consists of dense cytoplasm with a large active nucleus, and a very large central vacuole. In the growth of these cells the adjacent tissues present histolytic appearances similar to those seen in the same tissue when the endosperm enlarges. There is, therefore, so much evidence that the antipodal cells are able to secrete substance which acts in the way indicated upon the living cells.

When more than three antipodal cells occur they are arranged in pairs forming an irregular double row, recalling the condition in *Aster* (Chamberlain) and in *Diodia* (*pl. 9, fig. 5*). In some species the behavior of these cells is very irregular; one frequently finds several nuclei in the same cell, and the cells are sometimes much more slender in proportion than as represented in the figure (*pl. 9, fig. 5*). In all cases, however, the same observations already made with reference to the persistance of the antipodals and their nutritive relations holds good in *Asperula*.

THE EMBRYO

Of all the *Galieae* studied, the genus *Asperula* is most remarkable for the extreme development of the suspensor. In *A. setosa* (*pl. 8, fig. 4*) the haustorial cells attain a large size, and extend to a considerable distance from the suspensor into the endosperm. The amount of cytoplasm is not great, and is collected mainly at the distal ends of the haustoria, where the nucleus is to be found. At this point the growth of the organ takes place, so that we have here a very close analogy with the root hair in which, as Haberlandt * has shown, the nucleus and cytoplasm behave similarly.

* Ueber die Beziehung zwischen Function und Lage des Zellkernes bei den Pflanzen, Jena, 1887.

In this form, on account of the large size attained by the haustoria it is quite easy to see that, as they penetrate the endosperm, the process is accompanied by mechanical readjustment of the cells of the latter, without any destruction. *Pl. 8, fig. 5*, shows a later stage in the same or a closely related species, from which it will be seen that as the embryo grows older the haustoria becomes filled with cytoplasm. Meanwhile their proximal extremities become compressed and drawn out as a result of the pressure exerted on them by the growing endosperm. The suspensor, exclusive of the haustoria, then presents a fibrous appearance, with little cytoplasm, and is little more than an irregular tube joining the bases of the haustoria and the embryo. The haustoria in some instances are very narrow, and extend to a considerable distance, passing beyond the embryo proper. Such narrow ones remind one of fungal hyphae, which pursue an intercellular growth, or of the pollen tube with its analogous behavior.

In the other species, for example *A. azurea* and *A. galioides*, the suspensor develops haustoria which, instead of penetrating to a distance into the endosperm, confine themselves to rather narrow limits, while the immediately surrounding endosperm suffers histolysis. All the preparations of plants in which this behavior takes place show a perfectly normal structure in the haustoria, in which the cytoplasm is very dense and finely granular as in *A. galioides*, while in the material in which they are embedded no trace of structure is visible, nothing, in short, but the mucilaginous irregularly staining products of histolysis.

As the embryo becomes older the haustoria become separated from each other but still keep a normal appearance. The study of a complete series, of which *pl. 8, fig. 6*, represents a component of three sections, shows no union between several of the haustoria, although this fact cannot well be shown in a drawing.

The behavior of the suspensor in the various species of *Asperula* is therefore so different, as well as the relation between it and the endosperm, that we are prevented from interpreting the facts in the same way. In some cases, as described, the relation involves histolysis of the endosperm, which indicates that, in such cases, the suspensor secretes an enzyme.

The earlier cell divisions of the embryo proper are as described

in *Callipeltis*. It is to be observed, however, that the longitudinal divisions which are generally confined to the last four cells of the young embryo here take place also in a half dozen or more of the cells of the suspensor nearest the embryo (*pl. 8, figs. 4 and 5*).

Rubia tinctoria

(PLATE 9, FIGURES 1–6)

The nucelli of *Rubia* are recognizable by their form which in the young condition, before the integument has commenced to grow, is characterized by a sharp bend on the inner side of the funicle. The megaspore mother-cells are fewer in number and are of different proportions, being shorter and thicker than the same structures in the rest of the *Galieae* studied. Their nuclei are relatively larger (*fig. 1*). The tapetal cells fail here as elsewhere, and the division of the spore mother-cells is regular (*fig. 2*) giving rise to four equivalent spores. It is a common occurrence for several of the megaspores to divide with the result that a confusion is caused. The migration of the proper embryo-sac cell along the micropylar canal is accompanied by the usual divisions and the ultimate formation of an embryo-sac (*fig. 5*). The haustorial antipodal cell is broader and shorter than those of the foregoing forms. The other antipodal cells may be very small, and placed laterally or in some cases are quite large. In the former case they are filled with cytoplasm, in the latter case they have a cytoplasmic lining and the interior is filled by a large vacuole.

It is interesting to note that the embryo-sac nuclei do not cause the disintegration of the endodermis so rapidly as in other *Galieae*, and appear to force their way along the micropylar canal, without the immediate collapse of the impinging cells (*fig. 3*).

In many respects the features of the archesporium and of the embryo-sac present the same peculiarities as have already been described in *Asperula*. There is the same tendency towards the formation of supernumerary embryo-sacs, and the same characters are shown by the persisting megaspores (*fig. 4*), the nuclei of which are supplied with a scanty amount of cytoplasm, and are found lying freely in the irregular cavities left by the megaspore mother-cells.

After fertilization the endosperm grows very rapidly, and gets a large bulk. Although the growth of the embryo is immediate, and as rapid at least as in the other plants so far described, it is proportionately slower, so that in a fruit so large that one would naturally expect to find a large embryo, one finds, on the contrary, a young embryo without cotyledons. The endosperm has large cells and contains a very small proportion of plasma. For this reason the endosperm plasmolyzes very easily.

The suspensor of this form is very fully developed (*fig. 6*). The cell divisions are, at first, solely transverse. Soon, however, they become irregular and often strictly longitudinal, while all of the suspensor cells excepting a few disc-shaped cells near the embryo proper, and still fewer at the micropylar end of the suspensor develop into haustoria. The relatively greatest development is reached by the suspensor when the embryo proper has about eight to sixteen cells. The pressure exerted by the endosperm upon the suspensor, together with the direction of growth of the same causes the suspensor to be drawn out, so that the embryo proper appears to be anchored to the endosperm, which in this way is enabled to exert a tension upon the suspensor.

Crucianella

(PLATE 10, FIGURES 7–22)

Of the genus *Crucianella*, three species, namely, *C. gilanica*, *C. macrostachya*, and *C. herbacea* have been studied. These present certain anomalies which are of not a little interest in view of the close relationship between *Crucianella* and the rest of the *Galieae*.

The archesporium consists of 12 to 15 very large embryo-sac-mother-cells, which, however, vary between themselves in size. The largest occupy the more central position, and these are also distinguished by the completeness of their nuclear divisions; the other cells divide less regularly or not at all, and the more quickly show signs of degeneration. The cell walls between the mother-cells are very delicate, but are present and easily distinguishable.

The division of the megaspore mother-cells each into four grand-daughter cells is remarkably regular, and results in the formation of four megaspores which are alike in size, but not separated by cell walls. This feature, to which only very occa-

sional exceptions may be found, may be regarded from the phylogenetic point of view as a step further removed from the condition in Angiosperms in general in which the tendency to form cell walls may be regarded as an inheritance from forms in which the megaspores are in maturity free bodies.

Similar failure on the part of the megaspores to form cell walls has been reported to occur in *Eichhornia* * and in *Avena* † and is probably of much wider occurrence than at present supposed.

Certain authors—Juel, Murbeck and Koernicke especially—have recently concentrated attention anew to the constancy and significance of these divisions—the tetrad division. In addition to the evidence adduced from the character of the nuclear mitoses, to which reference is made in another part of this paper, the facts which speak for the morphological equivalency of the cells which justifies the use of the term megaspores as applied to them have been set forth at length by Koernicke.‡

Remarkable as is the regularity with which the megaspore mother-cell divisions take place, still more so is the further division, in very many instances, of *all the megaspores simultaneously*. If we regard these as the first embryo-sac divisions, which we are justified in doing from a comparative standpoint, we are forced to regard the eight resultant nuclei derived from a single megaspore mother-cell as representing four embryo-sacs lying tandem. It has been determined by actual count that some ovules may thus be supplied with a dozen young embryo-sacs. Of these two or three of those derived from the megaspores lying adjacent to the micropylar canal may commence to develop into functional embryo-sacs. Only one, however, normally attains full development. The very evident physiological as well as morphological equivalency of the megaspores in this plant irresistibly compels the comparison with the conditions seen in certain heterosporous vascular cryptogams, especially with *Selaginella*, in which the majority of the megaspores serve as nutriment for the functional ones.

* Smith, W. R. A Contribution to the Life History of the Pontederiaceae. Bot. Gaz. 15: 1898.

† Cannon, W. A. A Morphological Study of the Flower and Embryo of the Wild Oat, *Avena fatua* L. Proc. Cal. Acad. Botany, III. 1: 329. 1900.

‡ Studien an Embryosack-Mutterzellen. Sitzungsber. Gesellsch. Natur. und Heilk. Bonn, 1901.

The occurrence of such conditions in widely separated families is, however, a fact derived from comparative study, which warns us from inferring phylogenetic continuity. We are dealing here with *recurrent morphological structures*, called out in response to physiological necessities.

Of the four megaspores formed, although as just pointed out their activity is indicated by their tendency to further division, only the upper one, namely, the one furthest removed from the chalaza, develops into a functional embryo-sac. No exception to this rule has been observed. Instead, also, of enlarging directly at the expense of the other three by destroying and absorbing them, it moves into the micropylar canal, meanwhile growing at the expense of the adjacent tissue of the ovule (*figs. 18, 19, 21, 22*). In so doing the nucellar capping cells are destroyed. The fate of the remaining megaspores of the tetrad is indicated in *fig. 19*, in which they may be seen to have undergone partial disintegration, and to have been drawn forward toward the embryo-sac as if by suction. This appearance is quite constant, and is difficult to interpret in any other way. That the materials derived from them by their gradual disintegration and that of the other megaspores are used by the embryo-sac is shown by their gradual disappearance inversely to the growth of the embryo-sac.

For some time during the development of the embryo-sac, however, the tetrad masses maintain their normal appearance, and indeed elongate considerably, but generally show signs of degeneration before it is completely developed.

At the time the embryo-sac cell commences its migration down the micropylar canal certain changes take place in inner layers of the adjacent integument These consist in the rapid growth of the cells to many times their original volume, and the pronounced enlargement of the nuclei (*fig. 13*). These cells appear to be very active, and in some cases they fail to secrete cell walls, so that we find occasional cells provided with several nuclei. This behavior of cells, namely, their failure to form cell walls immediately, appears to be connected with a highly nutritive function, and recalls the conditions in young endosperm, in the suspensor of some *Leguminosae* (Guignard, *l. c.*), and in the megaspore masses described above. Examination shows that this cell mass

is a specialized portion of the ovule which is especially concerned in secreting starch, of which a very large amount is present, while it is at the same time absent from the rest of the ovule.

At the base of the archesporium the cells of the chalazal tissue appear, in a very early stage, just as the remainder of the cells of the ovule. As the integument develops, however, and therefore, as the archesporial cells increase in size, these chalazal cells take on a different character (*c.c.*, *figs. 7, 9 and 13*). From being small cells with a rather scant supply of cytoplasm, and relatively small nuclei, they become larger, their nuclei grow, and they become densely filled with cytoplasm. This appearance they maintain during the periods of growth of the archesporial cells, of their division into megaspores, and of the subsequent elongation of the tetrad masses. At the close of the activity of the latter the chalazal cells lose their supply of cytoplasm and return to the condition of the rest of the cells of the ovule.

We may therefore interpret them as physiologically active in the nutrition of the archesporium. Similar specialized chalazal cells have been described in many forms, more recently, however, in *Polypompholyx** and in *Stylidium.*†

The embryo-sac cell moves rapidly along the micropylar canal, and as it moves forward the integumental tissue closes behind it. The course taken may readily be traced by the more deeply staining cell walls of those cells lying next to the canal. The division of the embryo-sac cell follows the usual order, as heretofore described.

In this genus, however, the development of the embryo-sac is marked by the very sudden disappearance of the antipodal cells. Of all the preparations made, in not one have all three of the antipodals been seen, although they are developed, as indicated in *fig. 21, ant.* The polar nuclei have been seen, and several cases have been found where one antipodal nucleus appeared normal. All the evidence indicates, therefore, that the sudden death of these nuclei is a character of the genus. It must however be noted that the antipodal end of the embryo-sac extends some

* Lang, F. K. Untersuchungen über Morphologie, Anatomie, und Samenentwickelung von *Polypompholyx* und *Biblis gigantea*. Flora, **88**: 149–206. 1901.

† Burns, G. P. Beiträge zur Kenntniss der Stilidiaceen. Flora, **87**: 313–354. 1900.

distance backwards toward the archesporial tissue, and is in connection with the same by means of the micropylar canal.

The embryo and endosperm present no points of striking difference from the same structures already described in other *Galieae*.

Diodia Virginiana

(PLATE 12, FIGURES 1–12)

I am indebted to Professor Frank S. Earle for collecting and preserving material of this and the following species described.

NUCELLUS. STROPHIOLE AND INTEGUMENT

From the account already given of the origin in the *Galieae* of the nuclei and basal partition, we have seen that the former rise independently from the floor of the ovary, and that the latter even at maturity of the ovules reaches over to one-fourth the distance from the floor to the roof of the ovarial chamber.

In the forms now to be considered, however, a somewhat different condition is to be found. Here the basal partition originates at the same time with the nucelli, so that in an appropriate longitudinal section one sees a plate of tissue rising from the floor of the ovary, from the sides of which the nucelli, seen as hemispherical masses, take their origin (*fig. 1*). With the further development of the ovary, the basal partition and that formed by the upper parts of the carpels, grow with equal rapidity, so that at the time the embryo-sac is mature the floor and roof moities of the ovarial partition fuse at a point half way from the floor to the roof of the ovary. At this point, therefore, are inserted the funicles of the ovules, whose growth is such as to give rise to the amphitropous form (*figs. 2, 8, and 9*).

Early in the development of the ovule at the time when, in assuming the amphitropous position, its axis is passing through a transverse plane, a growth which superficially suggests an integument makes its appearance first on the morphologically lower sides of the funicle. Coincident with the origin of this organ which for our present purposes we call a strophiole, the single integument commences to develop as a ring-shaped fundament about the epidermal capping cells of the archesporium. The growth of the integument is such as to form a long micropylar canal, the mouth

of which is ultimately covered by the strophiole. Certain features of special interest attach to this organ which will now be described.

In the first place, the supply of vascular tissue to the ovule is confined to the strophiole. A single strand of the same passes through the funicle and upon reaching the strophiole divides, sending one branch, the chief one, to the chalazal region of the strophiole, the other toward the micropylar region (*a* and *a'*, *figs. 2, 8, 9*). The chalazal branch (*a*) presents at its extremity a sharp turn towards the spot at which lies the archesporium.

Secondly the limit of the strophiolar tissue is sharply defined by the presence of a plate of brown-walled cells (*sp.* in the figures), having the same cytological characters as the epidermal cells of the integuments, which also become brown. In the young ovule the strophiolar plate is not to be seen, and has its origin at about the time the embryo-sac reaches its definitive condition, in scattered cells which marked the position of the plate, and which increase in number until the sheet of tissue is complete. When this takes place there are no fenestrations in the plate excepting a sometimes smaller one at the extremity of the chalazal branch of the vascular supply. It ultimately becomes continuous with the epidermis (*epi*, *fig. 9*) and thus the ovule exclusive of the strophiole comes to be completely surrounded by a sheath of cells with scanty plasmatic content, and deep brown walls.

In the third place the strophiole is characterized by the occurrence of a large number of excretory cells which become filled with raphides. When the seed is mature the strophiole carries a heavy load of calcium oxalate. As many as two hundred of the raphide cells have been counted. The remainder of the tissue is composed of cells which do not differ materially from the parenchyma of the integument. From the foregoing facts, it must be evident that the strophiole is the seat of special metabolic activity, during the growth of the embryo and endosperm, and that the strophiolar plate is of no special hindrance to the passage of proper food materials used by the embryo and endosperm.

ARCHESPORIUM AND EMBRYO-SAC

The archesporium is laid down in certain hypodermal cells of the nucellus of any early age. No tapetal cells are cut off, nor is

there any further growth of nucellar tissue above the archesporium. The conditions then, are precisely as in the *Galieae* in which the archesporium is surmounted only by a group of epidermal capping cells. In the form, here being described, the archesporium, however, contains only one functional megaspore mother-cell (*fig. 3*) surrounded by a number—about a half dozen—of cells of similar character, but reduced in size, and as their later history shows, possessing usually no ability to divide or to act as embryo-sac fundaments. No instance has been found in which two embryo-sacs have been present in a single ovule, a witness to the reduced ability of these cells as compared with their homologues in the *Galieae*.

The functional megaspore, however, grows apace and is easily to be recognized by its size and appearance. Its cytoplasm, especially at its outer end, is of a loose reticular structure which, in this form in particular, is very marked. Whether by division this cell divides to form megaspores or not, I can not at present say. In the figure shown (*fig. 3*) the synapsis stage there represented indicates that such divisions do occur since the first division of the embryo-sac nucleus takes place, in a closely related plant, at a later stage. To say that a direct development of the megaspore mother-cell into the embryo-sac takes place would, however, in the absence of positive evidence, be gratuitous. We therefore assume that such is not the case until a more favorable opportunity is presented for more careful investigation of the point.

The embryo-sac cell, when the integument is well grown, is ready to commence its development. It is to be noticed that in the case before us the subsidiary archesporial cells do not suffer disintegration during the enlargement of the functional embryo-sac cell. The latter when fully developed pushes forward, causing disintegration of the epidermal capping cells and enters the micropylar canal. Down this it moves, dividing meanwhile so as to give rise to the usual complement of embryo-sac cells. The remaining undivided megaspore mother-cells follow the moving embryo-sac cell, and arrange themselves lengthwise in the archesporial cavity and the adjacent portion of the micropylar canal in such a manner as to form a continuous strand of elongated cells

connecting the embryo-sac with the archesporial cavity (*figs. 4, 5, 12*). Near this point, as above pointed out, ends the chalazal branch of the vascular tissue of the strophiole. It must be further pointed out that the chalazal tissue cells are elongated between the archesporium and the vascular tissue, completing the path along which we may believe passes a supply of food materials from the parent plant to the developing embryo-sac. The persistence of the subsidiary archesporial cells with normal appearance until the endosperm is well developed sustains this view.

The embryo-sac in form is cylindric and presents, so far as the egg apparatus and endosperm nucleus are concerned, no point of special note. The fusion of the polar nuclei takes place quite near to the egg. The synergidae have well developed beaks which have been described for many forms and which I have referred to in another part of this paper.

THE ANTIPODAL CELLS

The feature of particular note is, however, to be found in the antipodal cells, which possess the power to divide, and form a tissue of considerable extent. The number of cells has been counted in several instances, and varies from four to ten. Frequently the several component cells are not separated by a cell wall, in which cases two or more nuclei may be found in a common mass of cytoplasm. The last antipodal is tapering in form, and overlaps the adjacent subsidary archesporial cells (*figs. 6, 12*), so that there lies, between the endosperm and the chalazal end of the vascular tissue, a continuous strand of transporting cells. There can be no doubt of the activity of the antipodal cells in this regard because of the following facts: The antipodal cells exhibit a degree of active growth, they are at all times richly supplied with starch, a substance which is abundant in the embryo-sac during its whole time of development, and they do not disintegrate, but, on the contrary, maintain their form and normal appearance for a long time after fertilization, while the endosperm is in its earlier most rapid growth. In appearance they are apparently similiar to the antipodal tissue described by Chamberlain (*l. c.*) in *Aster*. The coincident persistence of the archesporial cells is also noteworthy in this connection.

THE ENDOSPERM AND EMBRYO

The endosperm is at first parietal, and arises by free cell formation. At a somewhat early stage the central cavity becomes obliterated by the growth of the endosperm cells toward the center. Walls are then secreted and the tissue then presents in the main the same appearance as the endosperm in the *Galieae*. The peripheral cells, which are more densely filled with cytoplasm than the rest, appear to play the rôles of digestive and absorptive cells before which the integument breaks down as the endosperm grows. The integument breaks down with the usual appearances accompanying histolysis, although the cells of the micropyle resist the digestive action rather more than the rest of the tissue. The cells of the middle part of the endosperm, as the latter reaches a considerable size, present, on the other hand, a quite different character. They are larger and have contents which stain in such a way as to suggest that they also are suffering histolysis. A column of such cells extends from the embryo two-thirds of the longitudinal distance through the endosperm. As the embryo grows in length it comes to occupy this space, displacing the cells.

The embryo is of remarkably slow growth in the earlier stages of its development. The early growth takes place in the usual way, forming a suspensor of a few cells which are totally devoid of such outgrowths as have been described for the *Galieae*. The spherical form of the embryo proper is reached only slowly, and meanwhile the endosperm grows so as to reach nearly its final size. The later development of the embryo during which the cotyledons are formed is more rapid.

Diodia teres

(PLATE 12, FIGURES 13–17; PLATE 13, FIGURES 1–10)

THE NUCELLUS AND STROPHIOLE

With a trifling difference in the configuration of the nucelli, due apparently to the somewhat different mechanical relations in the ovary of this species, their behavior and that of the basal partition is the same as that in *Diodia Virginiana* (*pl. 12, fig. 13*). The insertion of the funicle, however, is not so far removed from the base of the ovary on account of the somewhat less rapid development

of the basal partition. Quite soon the strophiole appears on the concave side of the funicle (*pl. 12, fig. 14*), and the ridge gradually extends to the opposite side. With further development the micropyle becomes entirely closed by the strophiole, which agrees with its homologue in *Diodia Virginiana* in being possessed of special excretory cells containing raphides in large numbers, and in being the organ in which the vascular tissue of the ovule is distributed. The cells adjacent to the vascular tissue are small and are more densely filled with plasma, and increase in size in approaching the integument. The latter is not delimited from the strophiole by means of the brown cells which have been seen in *D. Virginiana*, and which are absent from the ovule entirely. The epidermal covering of the funicle and part of the strophiole is strikingly developed, and has been described more fully in another part of this paper. It is sufficient at present to point out the fact that they are deep columnar cells with thickened walls, and form a collar of tissue about the funicle, but having no relation to the nutrition of the ovule (*pl. 13, figs. 1, 7, 8*).

THE ARCHESPORIUM AND EMBRYO-SAC

The archesporium is in all respects similar to that of *Diodia Virginiana* (*pl. 12, fig. 15*). Only one functional megaspore mother-cell is present which divides to form four megaspores (*pl. 12, figs. 16, 17*). One of these, probably the basal, judging from appearances, such as are seen, for example, in *pl. 13, fig. 2*, is the embryo-sac cell. This grows rapidly, becomes loaded with starch, and commences its migration along the micropylar canal. As the nucleus passes forward, a vacuole is formed behind it. This vacuole is also present in *Diodia Virginiana* (*pl. 12, figs. 2, 4, and 5*).

The embryo-sac when mature is comparatively short, and only three antipodals are present, and we notice that, although one of these is much larger than the others, it is nevertheless much reduced in length as compared with that cell in the forms previously described. The persistence of these cells for a considerable period, together with their heavy starch contents indicate that they have a considerable amount of activity. The functional activity of the antipodal cells even in this form where, to all appearances,

they are of less importance than in the other plants studied, is indicated by the distribution of starch. In the unopened flower the embryo-sac is crowded with this food material, which is, however, absent from the rest of the ovule. As the flower opens, and at the time of fertilization, the starch disappears from the embryo-sac, first from the egg pole, so that in an old flower starch is entirely absent from the embryo-sac, but has commenced to accumulate at the chalazal end of the ovule. After fertilization, starch reappears in the antipodal cells, and then in the growing endosperm, so that when the latter has considerably increased (*pl. 13, fig. 6*), the former are very rich in starch content. In this connection it is to be noticed, also, that the subsidiary archesporial cells soon disappear, and take no further part in the development of the ovule. They are, in fact, quite lost to view when the embryo-sac contains but two cells. The endosperm nucleus lies appressed against the egg cell for some time before division. The endosperm is of the parietal type (*pl. 13, fig. 6*), and its behavior is similar to that of the same structure in *Diodia Virginiana*, as is also true of the integument.

The shape of the ovary is such that the chalazal end of the integument becomes folded over the strophiole, the whole producing the curious effect shown in *pl. 13, fig. 8*.

The embryo is slow in developing, and no haustorial outgrowths occur. The cells of the suspensor are at first short, and disc-shaped and later lengthen, bringing the embryo deeper in the endosperm (*pl. 13, fig. 9*). That the suspensor is not an organ of only mechanical significance may be inferred from the occurrence in it of a great deal of starch up to the time, at least, when the cotyledons are well started.

Richardsonia pilosa

(PLATE 13, FIGURES 11–18)

Material in cultivation at the New York Botanical Garden.

In the main, this plant agrees with the two species of *Diodia* as to the development of the ovule and archesporium, and of the embryo. The following important points of difference are to be noted.

The functional megaspore enlarges and develops into the

embryo-sac *in situ*. In lengthening, however, it grows forward, and destroys the nucellar cap, so that these cannot be seen after the embryo-sac nucleus divides. No migration, strictly speaking, takes place, so that the antipodal cells appear in the position previously occupied by the archesporium. The few reduced subsidiary megaspore mother-cells are soon absorbed and are lost to view.

By the usual number of divisions the eight embryo-sac nuclei are formed, and the egg apparatus, polar nuclei and antipodal cells arrange themselves in an oval cavity. The antipodals are constantly three in number, and are in this plant all nearly of a size (*figs. 14, 15*). For some time they possess a large, deeply staining nucleus, finely granular dense cytoplasm, and a vacuole at their free ends, and present the appearance of certain glandular cells, especially the stigmatic cells in some plants, and of synergidae. This fact is important, as it indicates a considerable degree of physiological activity on the part of the cells.

After fertilization the embryo develops slowly, forming first by transverse cell divisions a row of disc-formed cells. The suspensor remains always a short organ, with no special adaptations. The endosperm is at first parietal, but early fills the cavity by equal centripetal growth on all sides. At such time as this occurs, there appear at the apex of the embryo certain very much enlarged cells of endospermic origin, with nuclei considerably greater than those of the rest of the endosperm cells (*fig. 18*). Beyond their size, as just indicated, these cells do not present any peculiarities, and it is therefore difficult to any whether they possess any special physiological peculiarities, although this seems probable. They correspond in general to similarly placed cells in other types described, as having a centripetally developing endosperm, differing from them chiefly in size.

As the ovule enlarges after fertilization the limiting cells of the strophiole take on the brown coloration already noted in *Diodia Virginiana*. This change spreads to the cells surrounding the end of the vascular bundle. The peculiar function of these cells, if such they possess, remains problematical. It is certain, however, that they exert no unfavorable influence on the passage of food solutions, whether they have any positive value or not.

Houstonia

(PLATE 14)

The two species of the genus *Houstonia* which have been studied are *Houstonia coerulea* and *H. longifolia*, both of which have been found to be in essential agreement.

The style, which in *Houstonia* is single, is provided with two stigmas, and arises by the concrescence of two ridge-like fundaments which develop, as in the *Galieae*, laterally and opposite to each other, in the inside of the hollow torus (*s*, *figs. 1, 2 and 3*). During concrescence a transverse ridge (*figs. 1, 2 and 3*) is formed on the inside of the ovary roof, which, by downward growth, ultimately divides the originally single ovarial chamber into two locules. This ridge, which may be described as hanging from the roof of the ovary, unites along its free lower border with a parallel, low broader ridge developed in the floor of the ovary. This floor ridge (*b*, *figs. 2 and 3*), which must be regarded as representing two fused carpellary margins, is not evident until the two rounded fundaments of the placentae (*p*, *fig. 1*) have reached considerable size. These two structures have the same position and appearance as the fundaments of the ovules in the *Galieae*. In the latter forms, however, the two carpellary margins produce each a single ovule; in *Houstonia* a knob-shaped placenta is formed in each locule occupying the same topographic relations as the ovules in the *Galieae*.

Each placenta soon begins to show a number of protuberant growths, which may early be recognized as the primordia of ovules. The development of these is of peculiar interest.

Up till the time when the archesporium is to be distinguished the course of development of the ovule is like that in the *Galieae*. A single row of epidermal cells cap the archesporium, but these cells, which in the *Galieae* remain without further division, in *Houstonia* suffer periclinal divisions (*fig. 4*), as do also the adjacent epidermal cells. This process is continued until the archesporium comes to lie in the middle of the nucellar mass. *No integument at all is developed;* indeed, the regular periclinal cell divisions which characterize the early stage in the development of the integument in the *Galieae* are absent. The suppression of the integument accounts for the absence of the micropyle.

By growth in all directions the mass of the ovule is increased, and finally a bowl-shaped form is attained, with the concave surface turned toward the placenta. This change in form is accompanied by lengthening of the funicle, which has histologically the appearance of being a part of the placenta, but which in reality is derived by the regular division of the cells (*figs. 8 and 10, ff*), which constitute a very short stalk in the younger condition.

It is interesting to note in passing that the "*nucellus nudus*" of Schleiden, which that botanist incorrectly thought to be found in certain Rubiaceae, is realized in *Houstonia*.

It must be evident that generalizations made heretofore with reference to the occurrence of ovules without integument in degenerate plants must fall to the ground.

THE ARCHESPORIUM

The archesporium consists of a single large embryo-sac-mother-cell, surrounded by a single layer of usually about six small slender suppressed ones which show no tendency to divide. They, however, do not all degenerate, but some at least take on special cytological characters and take up their position in the cavity vacated by the functional embryo-sac-mother-cell in its development (*fig. 9*). In this figure one may see two such mother-cells which have the appearance of glandular cells, resembling in this regard the antipodal cells. From the same figure it is also evident that some of the mother-cells persist in this character for a considerable period, until, at least, the completion of the embryo-sac.

When the growth of the nucellar cap has proceeded until the archesporium comes to lie in the middle of the naked nucellus, the division of the megaspore mother-cell takes place. Four megaspores arise by two divisions, of which, contrary to the general rule among the Rubiaceae studied, the basal megaspore becomes the embryo-sac cell. In *fig. 6*, in which the arrow indicates the egg pole, are shown the four cells, of which the basal is the largest. Its sister cell is small, while the remaining pair of cells are evidently destined also to be of small dimensions.

The embryo-sac cell develops into the embryo-sac *in situ*. *fig. 7* shows the two-celled, and *fig. 8* the four-celled, condition. The definitive condition is shown in *fig. 9*. In its growth, the

embryo-sac destroys the surrounding nucellar tissue (*fig. 8*), but more rapidly in the direction of the egg pole, and leaving the tissue about the archesporium intact. The suppressed megaspores, which are represented on either side the functional one in *fig. 5*, meanwhile enlarge somewhat, and a vacuole appears in the cytoplasm. In this condition they may be seen, when the embryo-sac is mature, occupying the space previously mapped out as the archesporium, behind the antipodal cells, to which they are very similar in cytological characters, differing only in size. The antipodals are all of a size, densely filled with finely granular cytoplasm, and having a large vacuole in the end adjacent to the endosperm cells. Soon after fertilization both the megaspores, which persist up till this time, and the antipodal cells degenerate, and are seen as irregular, deeply staining masses.

Before the endosperm nucleus commences to divide it is seen lying against the young embryo. The growth of the endosperm is at first parietal, remaining so until two or three irregular layers of cells have been formed. As the result of the rapid increase in amount of vacuolation, however, the endosperm cells increase in size so as to obliterate the enclosed cavity, thus passing from the parietal condition to that found in the *Galieae*, but by a different mode of development (*figs. 10, 11, and 12*).

The development of the embryo is exceedingly slow. From the condition, in which it has a rather characteristic cylindrical form, it becomes multicellular by transverse divisions which occur slowly. No haustoria are produced, nor is there any point of particular interest in the later development.

When mature the seed consists of a seed coat of a few layers of very much compressed cells derived from the outer zone of the integument, enveloping the endosperm, which, in turn, surrounds the embryo.

The cells of the endosperm are rich in proteids with a few scattered starch grains. The cell walls are moderately thick, while those of the outer layer of cells are considerably thickened.

The separation of the seed from the placenta takes place at the plane of the insertion of the funicle in the seed, along the plane, therefore, in which the growth of the funicular cells by division takes place (*ff*, *fig. 10*).

SUMMARY AND CONCLUSIONS

The results presented in the foregoing pages have been derived from a study of 23 species representing 9 genera of the Rubiaceae.

In view of the great size and complexity of the family as at present understood, any conclusions based upon so small a proportion of the whole segregate may be applied with probable truth only to the genera represented by the species studied.

Of the lot, the *Galieae* have been the most thoroughly studied, and this group has been found to present a high degree of homogeneity, and the characters ascertained, with one exception to be noted below under *5* may be received as applying with only slight differences to all the plants of *Galieae*.

1. In all the plants considered, excepting in those of the genus *Houstonia*, two ovules are present. Their primordia arise in the floor of the ovary on either side the floral axis, and develop in such a manner as to produce approximately anatropous ovules provided with a single integument and with a greatly reduced nucellus which is not to be distinguished except at an early age, when it takes the form of a cap consisting of a single layer of cells crowning the archesporium. In the Compositae this layer forms a complete investment of an unicellular archesporium. It would appear, then, that the nucellus in these Rubiaceae is suppressed, a view however which is hardly in accord with the facts; for the apparent lack of a nucellus such as we find in the Compositae, may be regarded as a result of the thickening of the tissue of the primordium about the sides of the archesporium and the origin of the much thickened integument nearer the morphological apex of the primordium. According to this interpretation the nucellus is marked by the more abundant growth of its sides and its intimate relation to the integument.

This circumstance, if, as I hold, a fact, leads to a difficulty n delimiting the nucellus as ordinarily defined, a difficulty however no greater than that encountered in defining any organ when viewed in the light of modern morphological conceptions.

2. In the *Spermacoceae* there is, in addition to the integument, a second outgrowth, derived from the funiculus and here called a strophiole. This structure contains the vascular supply of the

ovules and possesses also in large numbers special excretory cells which become loaded with raphides.

Similar cells are found in some *Galieae* in the immediate vicinity of the embryo-sac for some time before and after fertilization, and the rôle which the contents play in the physiological economy of the ovule is by no means clear.

It may turn out that in both instances the calcium oxalate is of some positive value, and the term "excretory" as used above must be regarded as provisional.

3. In *Houstonia* each locule of the ovary is provided with a club-shaped placenta bearing each a number of ovules. The topographic relations of a placenta in *Houstonia* and an ovule in the *Galieae* are the same, and no differences have been observed in their origin.

The ovules in *Houstonia* are relatively very small and of a very simple type in that an *integument is wholly absent.* There is accordingly no micropyle and the archesporium becomes deeply buried in the nucellar tissue by the growth of the capping cells and of the tissue at the sides of the archesporium toward the apex of primordium. The archesporium further consists of but one functional embryo-sac-mother-cell.

Two questions arise concerning the above comparison; first, whether we may regard the ovule of the *Galieae* and the placenta with its ovules in *Houstonia* as morphological equivalents, and secondly, whether we have here a case of correlation.

To the first we can give no positive answer at present since a more careful study of the origin of the primordia is needed. If such should prove to be the case we should have a sort of branching or compound sporangium, a most interesting condition if true.

To the second question a more decided answer in the affirmative may be given in view of the fact that *where the placenta is formed the ovules are arrested* both as regards the integument and archesporium and in total relative size. That the archesporium is really suppressed appears from the fact that commonly about seven embryo-sac-mother-cells are laid down, all but one of which fail to reach the normal size.

It must be added that the belief that a simple naked ovule, that is, one without any integument, is correlated with the para-

sitic habit of growth, must now be thrown aside. This conclusion was suggested inferentially by Goebel* in connection with his observation on the ovules of *Crinum Asiaticum* of which he remarked: "Sie zeichnen sich durch eine, sonst nur bei Schmarotzerpflanzen bekannte Eigenthümlichkeit aus, sie sind nackt, es fehlen die sonst in Ein- oder Zweizahl vorhandenen Integumente."

4. The archesporium throughout contains a number (7–15) of megaspore mother-cells, the largest number occurring in the species of the *Galieae*. Each megaspore—barring the arrested ones at the side of the archesporium—divides twice to form four megaspores, which, except very infrequently, are not separated by walls. This condition is comparable to that described as occurring with some frequency in *Eichhornia* † and *Avena*.‡ All the megaspores are both morphologically and physiologically equivalent. It is, in consequence, impossible to pick out with the eye the functional megaspore, which appears usually to be the outer. As Koernicke § has recently emphasized, the embryo-sac cell in the great majority of Phanerogams is derived from the last megaspore, *i. e.*, the one at the chalazal pole, because usually the divisions which give rise to the megaspores are such as to give the largest proportion of plasma to that cell, a phenomenon which he holds to be connected with its more favorable position with reference to the source of nutriment. This view finds support in the facts here summarized in so far that the larger number of megaspores and undivided megaspore mother-cells form a nutritive tissue surrounding more or less completely the embryo-sac cell which arises near the longitudinal axis of the mass. That the functional megaspore, *i. e.*, the embryo-sac cell is found near the middle, and not in the sides of the archesporium is due, I hold, to the mechanical relation between the cells brought about by the growth of the ovule which is such as to produce no unequal pressure on the archesporium.

* Biologische Schilderungen, 1: p. 129.

† Smith, W. R. A Contribution to the Life History of the Pontederiaceae. Bot. Gaz. 15: 324. 1898.

‡ Cannon, W. A. A morphological Study of the Flower and Embryo of the Wild Oat, *Avena fatua* L. Proc. Cal. Acad. Botany, III. 1: 329. 1900.

§ Studien an Embryosack-Mutterzellen. Sitzungsber. der Niederrhein. Gesellsch. Natur- und Heilkunde zu Bonn. 1901.

That, in forms in which a pluricellular megasporangium is present, any or all of the megaspores have the ability to develop into embryo-sacs proves in a most convincing manner the morphological equality of the megaspores, and the regular division of each of the megaspore mother-cells into four megaspores must be regarded as a true tetrad division.

At this point it is of interest to compare this result with those reached by Murbeck * who has studied *Alchemilla*, a representative of the Rosaceae. The presence of a multicellular archesporium in this family was first made known by Strasburger. † According to Murbeck twelve to sixteen mother cells are present, of which the peripheral and usually one of the centrally placed, fail to divide, and moreover *never give rise to embryo-sacs.* The remainder, six to nine in number, divide at least once and of the daughter-cells some divide a second time, and the granddaughter-cells thus formed are regarded, properly, as megaspores. It may be noted in passing that here there is no reduced number of chromosomes, reproduction being parthenogenetic. Of the megaspores thus produced, two or more may develop into young embryo-sacs, and what is of immediate and special interest in this connection, *in the same sporogenous cell-row, two or more may commence their development into embryo-sacs.* It thus appears that *Alchemilla* and *Crucianclla* are precisely comparable in this regard, while the evidence derived from the latter is still more final because of the actual division of all the megaspores derived from a simple mother-cell. Further cytological evidence that these are to be regarded as true tetrad divisions is presented on another page.

It is scarcely necessary to add that these facts accord an extraordinary strength to the view that the ovule is a sporangium.

In the *Spermacoceae* and *Oldenlandeae* the archesporium contains only one megaspore mother-cell of special size, from which the embryo-sac cell is derived. Several suppressed megaspores are present, surrounding the large megaspore mother-cell, which divides to form four megaspores, the basal of which forms the embryo-sac cell.

* Parthenogenetische Embryobildung in der Gattung *Alchemilla*. Acta. Reg. Soc. Physiogr. Lund, 11 : No. 7. 1901. For a more extended examination of the relevant literature see this valuable paper.

† Die Angiospermen und Gymnospermen.

The appearance of a pluricellular archesporium may by no means be considered as primitive. It has been shown by several workers to occur in widely separated families,* and with certainty may be said to have no phylogenetic significance. On the contrary, the meaning is purely physiological, and such conditions have arisen in various forms in response to similar conditions. When present they offer favorable nutritive conditions for the chosen embryo-sac. This view comports at least with the case of *Alchemilla* as interpreted by Murbeck (*l. c.*). The archesporial tissue not directly concerned in the formation of the embryo-sac takes activity or passively a nutritive rôle. If their rôle is passive they gradually disintegrate, and are absorbed. This appears to be the case in the *Galieae*, *Diodia teres* and *Richardsonia*. In the *Diodia Virginica* they grow chiefly in length and arrange themselves as a transporting tissue. As such they connect the embryo-sac with the vascular supply of the ovule, and persist for a considerable period after fertilization. In *Houstonia* the subsidiary megaspore mother-cells appear to persist till about the time the embryo commences to develop, and undergo regular and constant changes in size and form. These changes indicate their physiological importance.

5. The embryo-sac cell behaves in two ways. In *Houstonia* and *Richardsonia* it develops *in situ*. In the *Galieae* and in *Diodia* it moves forward out of its original position, breaking through the nucellar capping cells, and passing along the micropylar canal. Its passage is intercellular, and its action is so far analogous to the movement of the pollen tube, as described by Murbeck and myself. As it moves it derives nutriment from the disintegrating cells adjacent to it. The disintegration is such as to suggest very strongly the secretion of an enzyme by the embyro-sac.

The embryo-sac presents some remarkable features as regards the antipodal cells. These, in the *Galieae*, with the possible exception of one species of *Asperula*, are three in number, one of which is very much elongated. The free end of this cell is plunged into the mass of disintegrating megaspores and absorbs the same. The physiological importance of all the antipodals is indicated by

* For full citation of the literature see the papers of Murbeck and Koernicke (*l. c.*).

their structure, persistence, food content, and the behavior of the surrounding tissues.

The genus *Crucianella* offers an exception to the general condition in the *Galieae*. Although antipodals are developed no evidence has been obtained that they take on any special cytological characters. Indeed their tenure of life is so short that the three antipodal cells have not been seen at the same time. Their function is probably, therefore, at best but passive, and is carried out by the mere giving up of their substance in death to the embryo-sac.

In *Diodia teres*, also, the number of antipodal cells is three, but present a difference in that the long one is relatively much shorter, a feature which is undoubtedly correlated with the smaller amount of archesporial tissue. They may, however, not be considered as physiologically inactive since they secrete a large amount of starch, and persist for a long time.

In *Diodia Virginiana* the number of antipodals is greater, the number varying, so far as observed, between four and ten. These are arranged in a long series, physiologically equivalent to the single long antipodal in the *Galieae*. The subsidiary megaspore mother-cells, as above pointed out, persist and form a continuation of the series. The antipodal cells retain their normal character for a considerable period covering the earlier period of endosperm development.

In *Richardsonia* and *Houstonia* the antipodal cells are equal in all regards, and appear to have less permanent value. They acquire the cytological characters of glandular cells such as are found in certain nectarial tissues and stigmas, and are probably active in some kind of secretion. Their relative small importance as judged by their size is connected with the behavior of the embryo-sac cell and the much suppressed archesporium.

That, in the words of Westermaier (*l. c.*, Part I), we have to do, in the antipodals, with "an anatomical-physiological apparatus, and not with a useless rudimentary structure which may be understood only from the viewpoint of comparative morphology," * is evident from the facts as here summarized:

* It is of great interest in this connection to recall the remark of Hofmeister made over fifty years ago: "Die am Chalaza-Ende entstandenen, durch ihre beträchtliche Grösse oft sehr ausgezeichneten Zellen scheinen keine andere Bestimmung zu haben, als die der Verarbeitung des Nahrungsstoffes für den werdenden Embryo." Die Entstehung des Embryo der Phanerogamen, p. 59. 1849.

(*a*) The form and cytological structure of these cells, and the changes of their food content.

(*b*) Their tendency in some plants to multiply and form a special tissue, of the nature of conductive or nutritive tissue.

(*c*) The behavior of the surrounding tissues notably the archesporial cells, which are absorbed.

We may not overlook the case of *Crucianella*, for which evidence is lacking that the antipodals play any but a very brief, passive rôle.

7. The embryo in the *Galieae* develops rapidly, especially in its early stage, and possesses a remarkable feature in the presence of a highly developed embryonic organ, the suspensor, the cells of which elongate laterally, and penetrate the surrounding endosperm in an intercellular manner without causing any disintegration of the endosperm. These outgrowths are termed haustoria. Analogous organs are known in a number of forms, and probably occur in many more in one form or another. The function of the suspensor in these forms is therefore not alone to bring the embryo into favorable position with relation to the food supply in a mechanical sense, but to act as a temporary embryonic root. This function is secondary, the former being regarded as primary, as for example in the case of *Selaginella* * in which it appears to have no further significance.

A strikingly analogous condition appears in certain species of *Tropaeolum*, according to Dickson,† in which the embryo produces "branches from the base of the suspensor" which "serve as organs of nutrition for the developing embryo—*foetal roots*, in fact." These organs penetrate into the pericarp.

Similar organs have been described by Treub ‡ in the Orchidaceae and by Hofmeister,§ followed by Guignard || in the Leguminosae.

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* Pfeffer, W. Die Entwickelung des Keimes der Gattung *Selaginella*. Hansteins bot. Abhandl. 1 : No. 4.

† On the embryogeny of *Tropaeolum peregrinum* (L.) and *T. speciosum* (Endl. and Paepp.). Trans. Roy. Soc. 17 : Part 2.

‡ Notes sur l'embryogenie de quelques Orchidees. Naturk. Verh. K. Akad. 19 : 1879.

§ Die Entstehung des Embryo der Phanerogamen, 1849.

|| Ann. sci. nat. VI. 12: 5. 1881.

It is, further, not improbable that the peculiar features of the suspensor in some Cruciferae, *Alisma* and many other plants are connected with similar physiological conditions.

The embryo in the *Spermacoceae* and in *Houstonia* develops very slowly, especially in its early stages. We have to note here the complete absence of the adaptive characters in the suspensor seen in the *Galieae;* the suspensor is of a very simple structure, and upon anatomical evidence alone we might attribute to it only the mechanical functions above indicated. In view of the distribution of food stuffs as already described, however, we must recognize the suspensor in these forms as a less special haustorial organ than in the *Galieae*, but still an organ of that nature.

It may further be noticed that the production of haustoria from the suspensor of the embryo, and, so far as known, from no other part, is probably an expression of polarity in the embryo.

8. The endosperm is of two kinds, according to its method of development, corresponding to two of Hegelmaier's * types.

In the *Galieae*, the endosperm during its whole course of development fills completely the endosperm cavity (Hegelmaier's first type). The peripheral cells on the basis of their cytological character and the behavior of the adjacent tissues may be regarded as concerned in the secretion of an enzyme, and in the absorption of the food derived by digestion of the reserve food substances in the integument.

In the *Spermacoceae* and *Houstonia* the endosperm is at first parietal, later coming to fill completely the enclosed cavity (Hegelmaier's second type). In addition to the peripheral cells, which appear much as in the *Galieae*, the centrally placed cells in *Diodia* and *Richardsonia* take on a more special character with a problematical significance.

THE TETRAD AND EMBRYO-SAC MITOSES

(PLATES 9 AND 11)

The following account of the mitoses of the archesporium and of the embryo-sac is based upon a study of *Asperula montana*, *Crucianella macrostachya* and *C. gilanica.* Of the two genera,

* Untersuchungen über die Morphologie des Dicotyledonen—Endosperms. Nova Acta Akad. Naturforscher., **49**: No. 1. 1885.

Crucianella offered by far the more favorable material both on account of the size of the cells and of the absence of unequal pressure due to peculiarities in the development such as occur in *Asperula*. The former has therefore received more exhaustive study, although in regard to certain points *Asperula* has given important results.

When the ovule is young the embryo-sac-mother-cells are to be distinguished only by their greater size. During the early development of the integument, however, or even earlier, their cytoplasm becomes denser. At about the same time a large number of fibers appear in the cytoplasm traversing the cells longitudinally but in somewhat irregular fashion. The fibers are more or less curved and taper off at their ends.

Inasmuch as the embryo-sac-mother-cells attain a strikingly great length before the first division takes place (*pl. 10, fig. 16*) and have their cytoplasm crowded with these fibers, they present a very unique appearance. In some cases the fibers traverse the cells from end to end, bending aside to avoid the nucleus. The condition here described apparently corresponds to that found by Mottier * and Dixon † in *Lilium*, and by Duggar ‡ in *Symplocarpus*, during the earlier development of the embryo-sac mother-cell, excepting in certain matters of detail and interpretation.

From the figures of Mottier and Duggar one would judge that the fibrillar structures result from a rearrangement of the cytoplasmic reticulum. That the large thick fibers found by me in the developing embryo-sac-mother-cell are formed in the same way seems to me not to be the case, for, in addition to their great thickness, I have not been able to see a pulling out or distortion of the adjacent cytoplasm. Reference will be made to a possible interpretation of these structures beyond.

Again, according to Mottier, the orientation of the fibers in *Lilium* is not constant in different cells of the same stage of growth. They may run in various directions or they may sometimes form a dense felt-like zone about the nucleus. Further, this cytoplasmic differentiation disappears before the commencement of mitosis, and

* Ueber das Verhalten der Kerne bei der Entwickelung des Embryosackes und die Vorgänge bie der Befruchtung. Jahrb. wiss. Bot. 31 : 138. 1897.

† On the chromosomes of *Lilium longiflorum*. Proc. Irish Acad. III. 10 : 716.

‡ Studies in the development of the pollen grain in *Symplocarpus foetidus*, and *Peltandra undulata*. Bot. Gaz. 29 : 81. 1900.

by inference, has nothing to do with the formation of the mitotic figure. At the beginning of mitosis the cytoplasm shows again a uniform reticular structure, and the spindle of the first division takes its origin in radial or more or less irregularly placed fibers which penetrate the nuclear cavity, and form a multipolar spindle primordium.

With regard to the disappearance of the earlier formed thick fibers I am not able to establish a parallel in the Rubiaceae, for, in the embryo-sac-mother-cell in the plants studied they persist until the earlier stages of mitosis, at least through diakinesis. That they are in some way connected with the kinoplasmic figure during mitosis would appear from the circumstance that their ends on reaching the nucleus bend and run as figured in Mottier's *pl. 2, fig. 17*, of the paper referred to. This condition, as seen in *Crucianella macrostachya* is shown in *pl. 11, fig. 37*. From this and the adjoining figures it will be seen that the origin of the spindle is multipolar, and, with the possible exception of the peculiar behavior above described, corresponds to the descriptions of Osterhout * and others. The definitive spindle of the first division is strictly bipolar, and differs in the three plants in one or two details of form only.

In *Crucianella gilanica* the spindle is of very regular, broad, oval form, with sharply-pointed ends; in *C. macrostachya* it has a looser, more slender form, with attenuated ends, while in *Asperula* this character is still more accentuated. Such differences may in the main be regarded as inconstant and of no general importance, and may in many cases also be appearances referable to the plane in which the material happens to be cut. Insufficient observation of this point may very easily lead to false impressions, as Strasburger † has hinted, especially with reference to the character of the spindle poles.

Generally the ends of the spindle poles lie freely in the cytoplasm, inasmuch as the spindle axis usually lies parallel to the longitudinal axis of the cell, which, as already shown, is very long.

* Ueber Entstehung der karyokinetischen Spindel bei *Equisetum*. Jahrb. wiss. Bot. 30: 5. 1897.

† Ueber Reductionstheilung, Spindelbildung, Centrosomen und Cilienbildner im Pflanzenreich. Jena, 1900.

Occasionally, however, the spindle is found to lie obliquely, and one or both ends may become connected with the ectoplasm.*

In no case is a centrosome or centrosphere to be found. I have been able to follow finely-pointed spindles to their extreme end without finding any trace of the body which can without doubt be regarded as such. In a recent paper by Meves and von Korff on the Myriopoda, † the "centralkörper" are described as lying very near to the periphery of the cell, and are apparently not directly in connection with the spindle. The latter, however, is not pointed, while its fibers nevertheless are directed toward the kinetic centers.

Thus is formed a condition in which the centrosomes are considerably removed but still in control of the spindle ends.

In spite of the obvious difference in the character of the spindle itself, I was led to examine carefully every part of the cytoplasm lying in or near the spindle axis, but with a negative result.

The multipolar origin of the spindle in certain plant cells has been for some time regarded by the majority of botanists as speaking against the existence of the centrosome in plants in which the spindle has such an origin. Although a contrary view has been held by Guignard ‡ it would still appear that the former position is more consonant with the facts as they are at present understood.

For we would expect in such cases either as many centrosomes as spindle ends, or two whose influence would be exerted over the whole kinoplasmic figure (archoplasm). The former is shown to be the case in the development of the curious worm-shaped spermatozoon in *Paludina*, an account of which has lately appeared. § According to Meves the centrosphere of the primary spermatocyte contains a number of central granules which act as a unit. In the second mitosis the granules (Centralkörperkörner) separate and take a position in the periphery of the cell, and from these as centers are formed a number of half or partial spindles. The result is a picture which resembles in its later development to some

* Ectoplasm is here used to signify the "Hautschicht" of the Germans.

† Meves, Fr, and von Korff, K. "Zur Kenntniss der Zelltheilung bei Myriopoda. Archiv mik. Anat. und Entwickelungsgeschichte, 57: 481–486. *pl. 21.* 1901.

‡ Centrosomes in Plants. Bot. Gaz. 15: 158. 1898.

§ Meves, Fr. Ueber die sog. wurmförmigen Samenfäden von *Paludina* und über ihre Entwickelung. Mitth. Verein Schles.-Holst. Aerzte. 10: No. 1. 1901

degree the multipolar spindle primordium in plants, to which the author unhesitatingly compares it, with the inference that the plant cytologists have still overlooked the structures in question. But the comparison is without warrant, for an examination of the facts shows that we are dealing with two different modes of action.

The origin of the spindle is in the two cases quite different. In *Paludina* it is in the periphery of the cell, while in the higher plants it is at the nucleus. The development of the spindle is in the former therefore centripetal; in the latter centrifugal. We fail therefore to see any warrant for the conclusion that there is any parallel between the phenomena described by Meves, and those seen in the formation of the plant spindle of multipolar origin.

The parallel fails also in the following regard. In *Paludina* the spindle fibers develop from the centers. In plants, even admitting the existence of centers, the fibers are developed to a very considerable degree before the centrosomes, or centrosome-like bodies, when such are recognized, appear.

For the present, therefore, we must adhere to the view that the centrosome is absent from the higher plants.

We do not attempt to meet in detail the statements in certain recent papers to the contrary. * It is quite impossible to do this except by working with the same materials and methods, and this has not been done by me.

Nor, as Strasburger (*l. c.*) has shown, is positive evidence against the occurrence of the centrosome in higher plants wanting. Repeated studies on pollen development have been carried out, showing that the ends of the spindle find an insertion in the ectoplasm and the results of my own observations tend strongly to confirm the view that the ectoplasm serves in many instances as a place of connection in those cells in which the spindle is long enough to bridge the distance from side to side. One instance (*Asperula*) was seen in which a pluripolar diarch spindle had its four apices (appearing in a single section) were all inserted in the ectoplasm (*pl. 9, fig. 16*).

* Bernard, Ch. Recherches sur les sphere attractions chez *Lilium candidum*, *Helosis guyanensis*, etc. Jour. de Bot. **14**: 118, 177, 206. 1900.

Yamanuochi, S. Einige Beobachtungen uber die Centrosomen in den Pollenmutterzellen von *Lilium longiflorum*. Bot. Centralbl. Beihefte, **10**: 301. 1901.

Schaffner, J. H. A Contribution to the Life History and cytology of *Erythronium*. Bot. Gaz. **31**: 369. June, 1901.

When, however, the true apex of the spindle does not insert itself immediately in the ectoplasm, one may usually discover a fine strand of kinoplasm extending from the apex of the spindle to the ectoplasm (*pl. 9, fig. 10*).

In further support of the view that the spindle often stands in some intimate relation with the ectoplasm I may cite the instance from which fig. 4 of Pl. 9 was taken. The axis is here oblique to the optical plane, and one pole is seen to end distinctly at a point from which extend fibers in a somewhat radial fashion. Careful examination revealed the fact that the radially placed fibers lay in the peripheral layer of the cytoplasm, that is in the ectoplasm, and the latter therefore appears to bear a distinct mechanical relation to the spindle.

In many cases in which the dimensions of the cell are much greater relatively to the size of the spindle such attachments have not been found. This lack is especially obvious in the large embryo-sac-mother-cell of *Crucianella*, in which, however, as in the pollen spindles, extra-nuclear "supporting fibers" may be observed to run out from the spindle apices to the ectoplasm in the direction of the equator (*pl. 11, figs. 16, 17*). Similar conditions prevail in the pollen mother-cell in *Crucianella macrostachya* (*pl. 11, fig. 35*), where but a single row of sporogenous cells occurs in each locule of the anther. The cells are relatively large and the mitotic figure in both the first and second divisions lies freely in the cytoplasm. In this instance neither the insertion of the spindle poles, nor of the extra-nuclear supporting fibers in the ectoplasm could be seen with certainty. Indeed the orientation of the spindle fibers during the second division is often such as to preclude the possibility of the insertion of one of the poles at least, as will be seen in *pl. 11, fig. 35*, which shows that the axes of the two spindles lay in the same plane at right angles to each other; unless, indeed, we may expect to find the pole of one spindle passing through the body of the other.

In the developing pollen in many plants a distinct zone of very granular cytoplasm has been described by Juel,* Lawson, †

* Die Kerntheilungen in den Pollenmutterzellen von *Hemerocallis fulva* und die bei denselben auftretenden Unregemässigkeiten. Jahrb. wiss. Bot. 30 : 204. 1897.

† Some observations on the Development of the Karyokinetic Spindle in the Pollen mother-cells of *Cobaea scandens*. Proc. Cal. Acad. Botany, III. 1 : 169. 1899.

Byxbee, * Williams, † and others, and it has been suggested by Strasburger that, in those spindles of which the ends do not reach the ectoplasm, or in the absence of other mechanical support, the pericaryoplasm (of Lawson) may serve that purpose.

I have observed this zone in the plants under consideration, but in instances the poles of the mitotic figure reach the ectoplasm (*pl. 11, fig. 2*). In this event the zone thins out as it approaches the spindle pole. In the pollen mother-cell of *Crucianella macrostachya* this zone has not been observed and the spindle appears to lie quite freely and without any special mechanical relations.

The amount of variation in the observations of the topographic relations of the spindle ends leads to the suspicion that we are yet unable to form a satisfactory explanation of them. The most far reaching interpretation among the botanists is that of the Strasburger school, and is based upon the mechanical conception that the spindle is made up of contractile fibers (Zug-fasern) which, in order to pull apart the chromosomes, must have a more or less rigid mechanical support. This has been found in the ectoplasm, in the pericaryoplasm, in the vacuoles,‡ or the spindle ends may be buttressed by extra-nuclear supporting fibers.

That such mechanical relations as described by Strasburger and others really exist we may not doubt. All the appearances lead irresistibly to that conclusion. But I am by no means convinced that we may infer from these appearances anything as to the intimate workings of the mechanism, and the contractile fiber explanation may have to undergo perhaps a considerable degree of modification before it may be accepted as satisfactory.

Reference has already been made in another part of this paper to the absence of cell walls between the megaspores. It will be seen from *pl. 11, fig. 20*, and *pl. 9, fig. 23*, that the connecting fibers are formed, and the thickenings indicative of the cell plate are present. In *Crucianella* the presence of these fibers determines the appearance of the cytoplasm for some time (*pl. 10, fig. 9*). At the end of the third division in the same plant the nuclei are

* The Development of the karyokinetic Spindle in the Pollen Mother-cells of *Lavatera*. Proc. Cal. Acad. Botany, III. 2 : 63. 1900.

† The Origin of the karyokinetic Spindle in *Passiflora coerulea* Linn. Proc. Cal. Acad. Botany, III. 1 : 189. 1899.

‡ Strasburger, l. c.

arranged sometimes in two rows, and the connecting fibers run from one nucleus to the other in such a manner as to recall Mottier's* figure of the four nuclei in the upper end of the embryo-sac in *Helleborus foetidus*, and the appearances which one usually meets with during the formation of cell walls in endosperms (*pl. 10, fig. 18*).

The prophase of the first division in both pollen and embryo-sac-mother-cells is characterized by the stage known as diakinesis (of Häcker), in which the chromosome pairs become condensed into short, thick rods which lie parallel or become partially twisted about or crossed upon each other. The members of each pair may fuse at one or both ends, and as the result of more or less separation in the middle, may take also the form of rings either completely closed, or open at one point. Between these more definite forms the chromosome pairs may assume all sorts of intermediate conditions (*pl. 11, figs. 1, 14, 32, 37, 38*).

In some instances the members of the chromosome pairs may be separated from each other for a considerable distance, and the linin strands which unite their ends, may under such conditions be seen with the greatest clearness (*pl. 9, fig. 21, a*). In *Galtonia candicans*, according to Schniewind-Thies † the same behavior has been noted.

The formation of the rings takes place much more completely and earlier in *Asperula* in which genus also the condensation of the large loose rings into small thick ones may be followed with ease (*pl. 9, figs. 1 and 2*). The appearances so presented recall the figures of vom Rath ‡ of the chromosome rings in *Gryllotalpa* excepting, however, that no phenomena of tetrad formation (in the sense of the zoologists) may be observed.

During the prophase of this division the number of chromosomes may in these forms quite easily be determined and with a high degree of certainty has been found to be *one-half the usual number in the sporophyte*. The reduced number, which has been determined by counts, not only in the prophases, but in the ana-

* Ueber das Verhalten der Kerne, etc. Jahrb. wiss. Bot. 1897.

† Die Reduction, der Chromosome Zahl und die ihr folgenden Kerntheilungen in den Embryosacmutterzellen der Angiospermen. Jena, 1901.

‡ Zur Kenntniss der Spermatogenese von *Gryllotalpa vulgaris*. Arch. Mic. Anat. 1892.

phase of the first and second pollen division and in the first, second, third and fourth embryo-sac divisions, is in *Crucianella* the hitherto unobserved and surprising number ten, in *Asperula*, twelve.

These numbers, however, are believed, on the basis of a large number of counts at different times, to be inconstant. In *Crucianella* eight to eleven have been counted, and in *Asperula* a similar amount of variation has been observed. Allowing for error in counting, which, in these plants is not great, both on account of the smallness of the cells (with the consequent frequency with which the whole nucleus appears in a single thick section) and of the number of chromosomes, I believe it must be maintained that *variation in this regard occurs*, and that this is a fact which has heretofore received insufficient recognition.

The condensation of the chromosome pairs proceeds all through the prophase until the equatorial plate has been completed, when they take the form of a double Vs, one of which lies above and one below the equatorial plane, with their angles directed toward the axis of the spindle. This arrangement is difficult to recognize in metaphase on account of the extreme condensation of the chromosome, but in very early anaphase may be seen with sufficient distinctness.

My observations and conclusions appear to coincide with those of Duggar* for *Peltandra*. That author's interpretation of his figures of the corresponding division in *Symplocarpus* as indicating a qualitative division, however, would in my judgment seem not to be justified. For the chromosomes are here, as represented in *pl. 1, figs. 7 and 7a* of Duggar's paper, of double V-form with the angle directed toward the center of the spindle. These separate first at the angle, and the degree of similarity in the two plants is so great as to render them susceptible of but a single interpretation, which is opposed to the view that there is a qualitative division, unless it can clearly be shown that the separation of the limbs of the V is a separation, not at their ends, but across the middle of the chromosomes.

Attention should further be directed to the above mentioned observation, namely, that in diakinesis and the later prophase the

* Studies in the development of the pollen grain in *Symplocarpus foetidus* and *Peltandra undulata*. Bot. Gaz. 19: 81. 1900.

ends of the chromosome pairs do not invariably fuse even when they take the form of rings. With the approach of metaphase the two members if separated become laid together. The fixation of the fibers then takes place somewhere between and not at the ends of the chromosomes, so that the possibility of the occurrence of a transverse splitting of the chromosomes at this time, as suggested most recently by Schaffner * for *Erythronium*, seems to me to be excluded.

If the ends of the chromosome pairs always fused completely it would probably be impossible to tell whether the breaks during anaphase occurred at the points of fusion or somewhere between these. When, however, such a fusion does not take place the simpler and more obvious interpretation does not involve the idea of a reducing division.

The separation of the daughter chromosomes takes place with extreme regularity but curiously enough with quite constant differences in the two genera. In *Asperula* the ends of the daughter Vs separate simultaneously and the chromosomes take with little variation the form of a conventional heart. This is to be explained by the shortness of those bodies and the point at which the fibers are inserted (*pl. 9, figs. 3, 22*).

In *Crucianella*, on the contrary, the ends of the V-formed segments scarcely ever separate at the same time. The ones which remain united the longer are attached to each other with so great a degree of firmness that it is only after the greater mass of each daughter chromosome reaches about half the distance to the spindle poles that they finally separate (*pl. 11, figs. 2, 3, 16, 17, 18, 39*). The forms taken by the separating chromosomes under these conditions have received special study, and all of them suggest very definitely the behavior of plastic masses under tension. Examination of the detailed representations on *pl. 11* (*fig. 3, a–f; fig. 18, a–g*) will reveal this point quite clearly. Especially instructive are such forms as shown in *fig. 18, a*, as they bear on the question of transverse division. Were the chromosome here breaking transversely and not undergoing separation at united ends, it is difficult to see why such a bulge at the point of separa-

* A Contribution to the Life History and Cytology of *Erythronium*. Bot. Gaz. 31: 369–387. 1901.

tion should occur. On the other hand, it is quite easy to understand such an appearance on the supposition that a plane of adhesion exists at that point.

Whether the unequal separation of the daughter chromosomes is due to the failure of the mantle fibers to exert an equally distributed pull upon them, or to the fact that the fusion of the chromosome ends is not equal cannot be determined. It is a further point worthy of note that the two free ends of an incompletely separated chromosome pair are always directed away from the spindle axis, as if the mantle fibers were stretched along a resistant surface. After the separation of the daughter chromosomes is complete, a readjustment of tensions takes place so that the heart-shaped form spoken of in connection with *Asperula* is approached (*pl. 11, figs. 4, 16, 17, 18, g*).

During late anaphase a second longitudinal splitting of the chromosomes is seen with a fair degree of clearness (*pl. 9, figs. 6–9*). On account of the shortness of the resulting chromosomes, however, it is not easy to determine the forms which they take. For the most part they appear as pairs of straight rods, although some evidence that they are slightly bent into a V is seen. It is not at all improbable that a considerable amount of readjustment in the relations of mantle fibers and chromosomes takes place and this would explain the change in the shape of the chromosomes.

The appearances here described have been constantly seen in a large number of cells and there is very little doubt that the first division in *Asperula* is heterotypic in the sense adopted by Strasburger (*l. c.*, 99).

The corresponding longitudinal splitting of the chromosomes in *Crucianella* does not take place so early as in *Asperula*, and may be seen with clearness only in the telophase. *Pl. 11, fig. 5*, represents such a stage. It appears not possible to resolve the chromosome pairs thus formed during the whole of the period extending from this time till the metaphase of the second division; for as shown in *pl. 11, Fig. 6*, the pairing is indistinguishable, although a completely resting condition, as described for *Larix* by Juel,* in

* Juel, H. O. Beiträge zur Kenntniss der Tetradtheilung. Jahrb. wiss. Bot. 35: 626. 1900.

Pellia, by Davis,* in *Asclepias*,† by Strasburger, and in certain Liliaceae by Schniewind-Thies ‡ has not been observed to occur.

From the facts above presented it will be seen that in *Crucianella*, as in *Asperula*, the first splitting of the chromosomes is longitudinal. In early anaphase the daughter rods which open out from a double V-form into rings, separate finally at the ends of the limbs of the V, the angles being directed toward the pole. Later a second longitudinal splitting appears, the formation of granddaughter rods being completed before the close of the first mitosis. This division is, therefore, heterotypic and corresponds in essential details to the heterotypical mitosis in the spermatocytes of the salamander as described by Flemming.

The final evidence for this conclusion in regard to the embryo-sac-mother-cell has not been obtained without any doubt, but I believe that we may conclude from the otherwise complete correspondence in the two cases that the first embryo-sac-mother-cell division is also heterotypic.

The resting stage occurring between the first and second divisions is characterized by its short duration, and by the varying degree of diffusion of the chromatin. This variation is considerable not only among related species, but is evident in comparing the pollen and embryo-sac tetrad divisions in the same plant, as Strasburger § has observed to be the case in *Lilium*. It is notable that in the Rubiaceae also the daughter nuclei of the pollen mother-cell enter the resting stage less completely than in the corresponding nuclei in the ovule. If this prove to be generally true we may attribute the behavior to the closer analogy between the tetrad divisions in pollen and those of cryptogams, and the greater irregularity in the tetrad divisions in the ovule to the changed conditions which have been brought about in that organ.

Although the variation in the character of the resting stage is

* Davis, B. M. Nuclear Studies in *Pellia*. Ann. Bot. 15 : 147. 1901.

† Einige Bemerkungen zu der Pollenbildung bei *Asclepias*. Ber. deutsch. bot. Gesellsch. 19 : 450. 1901.

‡ Schniewind-Thies, T. Die Reduction der Chromosomezahl und die ihr folgenden Kerntheilungen in den Embryosacmutterzellen der Angiospermen. Jena, 1901.

§ Ueber Cytoplasmastructuren, Kern und Zelltheilung. Jahrb. wiss. Bot. 10 : 252. 1897.

real and considerable, all the cases studied are alike in the absence of a nucleolus, in the indistinctness of the nuclear membrane, which appears as if surrounded by an ill-defined zone of fine kinoplasmic fibers running in various directions, and in the loss, at least so far as direct observation can take us, of the individuality of the granddaughter chromosomes, even when, as in *Crucianella*, the second splitting takes place in early telophase.

The occurrence of a more or less complete resting stage at the end of the first division is a phenomenon of wide occurrence among the phanerogams. Authors are not agreed, however, as to the degree into which the daughter nuclei enter at this stage. More recently Schniewind-Thies has found a considerable amount of variations in a number of forms studied comparatively by her. It appears, therefore, that we may explain this disagreement on the ground of the occurrence of a considerable degree of variation in this regard.

It does not appear to be necessary to be concerned about the loss of individuality by the chromosomes under the circumstances at least so far as the question of reduction is involved. A second longitudinal splitting being demonstrated to occur before this takes place, we are compelled to believe in the absence of positive evidence to the contrary that the rehabilitation of the chromosomes is complete. The Weissmannian interpretation once shut out, it remains for us to explain the variable degree into which the granddaughter nuclei enter the resting condition apart from it. I cannot agree with Davis, nor do I find for him any justification in the literature of the subject, either on the zoölogical or botanical side of the question, when he remarks "This conception * is intimately concerned with, and necessarily a part of, the recent studies of Guignard and Strasburger on the double longitudinal splitting of the chromosomes." (*l. c.*, p. 159.)

Indeed Strasburger himself has recently shown that in *Asclepias* (*l. c.*) a complete resting stage, with a nucleolus, is formed between the first and second pollen divisions, without making any remark further than to call attention to the fact.

* That the chromosomes maintain their individuality in the daughter nuclei after the first mitosis of the pollen mother-cell.

THE SECOND DIVISION

During the prophase of the second division in the embryo-sac-mother-cell delicate radiating fibers in great numbers are found surrounding the nucleus and extending from the same in all directions (*pl. 11, fig. 42*). In certain cells where the walls come into contact with the nucleus these fibers then appear in sections as if there were two distinct systems arising from the opposite sides of the nucleus. They thus simulate asters. In point of fact, however, they form a zone about the nucleus lying parallel to the compressing cell walls (*pl. 11, fig. 15*).

Such radiations have been figured and described by many authors, but accounts are, in spite of a multitude of detail, still in such a condition as not to warrant us in believing that we as yet understand fully the relation between the nucleus and these radiations.

Their resemblance, however to certain appearances is parthenogenetically developing eggs of *Toxopneustes* after treatment with magnesium chloride has led Wilson * to make the following suggestion which I give in his own words.

"The formation of a perinuclear zone in the magnesium eggs strongly suggests the accumulation of 'kinoplasm' about the nucleus in the early prophase of cell division in the higher plants, as described by Osterhout and Mottier, and a number of later observers, though the later phenomena are in many respects very different."

According to Wilson's direct observations on the living Mg-eggs, a primary radiation appears surrounding the nucleus and extending far out to the periphery of the cell. This radiation is interpreted as a flow of hyaloplasm which, in part at least, gives rise to the appearances making up the "aster." The gradual disappearance of these radiations is accompanied by the formation of a clear perinuclear zone, followed by "enlargement of the nucleus and the disappearance of the nuclear membrane accompanied by a reduction of the rays almost to the vanishing point." (*l. c.*)

The comparison is strengthened by the facts described earlier

* Experimental Studies in Cytology, I. A cytological Study of artificial Parthenogenesis in Sea-Urchin Eggs. Archiv Entwickelungsmechanik der Organismen. 12: 529. 1901.

in this paper in connection with the development of the embryo-sac-mother-cell. The numbers of fibers then seen and their apparent behavior with respect to the nucleus, as already indicated, in many ways harmonize with Wilson's suggestion. If further study should show this harmony to be complete, we would then have strong grounds, in the absence of direct observation of the living material, for the belief that these fibers are currents of viscid material (kinoplasm, hyaloplasm) the view first taken by Auerbach, and later adopted by Fol, Strasburger † and others in modified form.

It would appear that a further and more particular study of the behavior of the kinoplasm during the prophase in plants from the suggestive point of view just indicated would have a distinct bearing upon the vexing problem of the nature of the fibers.

In the prophase of the second division the granddaughter chromosomes reappear in *Crucianella* as pairs of rods lying parallel to or partly twisted about each other and lying on the nuclear walls (*pl. 11, fig. 21*). In *Asperula* the chromosomes are so short that they appear as pairs of spheres (*pl. 9, fig. 16*), though in metaphase they frequently appear as pairs of short rods, one lying above and one below the equatorial plate. The mantle fibers are usually attached to the chromosomes at their ends, one chromosome lying above and one below the equatorial plane (*pl. 11, figs. 8, 22 and 35*). Occasionally, however, they may be attached at some point along their length. During anaphase, therefore, the chromosomes have the form of short rods with their longitudinal axes directed toward the spindle poles (*pl. 11, fig. 24*), or less frequently of bent rods with the loop similarly directed (*pl. 11, fig. 25*). There are some minor differences between the form of the chromosomes in the second pollen- and embryo-sac-mother-cell divisions. In the latter the rods are longer and more slender (*pl. 11, fig. 24*); in the former shorter and thicker (*pl. 11, fig. 9*). On account of this fact and the further one that in *Crucianella gilanica* the spindles are very small in the pollen cells, the character of the structures is rather difficult to determine. In *Crucianella macrostachya*, in the anther locules of which but one row of pollen mother-cells is present, the opportunities

† Zellbildung und Zelltheilung. 3 Aufl., 367.

for observations are better, and here the chromosomes are seen distinctly as paired rods, with the fibers for the most part attached to their end (*pl. 11, figs. 35 and 36*).

The contrast offered between the appearances seen during the first and second divisions are well seen in *pl. 11, figs. 16 or 17, and 24*, all of which have been taken from the same ovule. The spindles shown in *figs. 16 and 24, pl. 11*, may indeed be seen in the same field in adjacent megaspore mother-cells.

According to the interpretation here given of the behavior of the chromosomes the application of the facts to the Weissmannian view of reduction is made impossible.

That, however, a real reduction in the quantity of chromatin occurs as well as a reduction in the number of chromosomes has been held by Guignard, according to whom the second division which follows on the first without pause reduces the nuclein which the grand-daughter nuclei receive by a half, compared with the amount which the ordinary nuclei of the sporophyte have. Such reduction, however, results in equivalent cells as regards their hereditary qualities.

A reduction in this sense certainly occurs in the plants under consideration, if we may argue from the relative sizes of the nuclei. The figures which present the facts, namely, *pl. 11, figs. 6 and 13*, are drawn to the same scale and show that the nuclei at the end of the second division are much smaller than those at the end of the first. True, the cells themselves are also smaller and this indicates that the cause of such quantitative reduction is to be found in the rapidity with which the divisions follow each other, thus preventing an intervening period of growth.

THE THIRD DIVISION

The resting stage at the close of the second division is complete, a nucleolus is formed, and a considerable pause intervenes before the third division takes place.

It has been already pointed out on another page that in the genus *Crucianella* the megaspores are unique in that they are all functional in so far that they frequently undergo the first embryo-sac division. All the divisions which take place in this way are alike in character, that is they are typical mitoses. The further

divisions of the supernumerary megaspores have not been observed in any other genus, and in all probability do not take place. It would appear from comparative study that the large size of the megaspores and the absence of compression by the surrounding tissues offer favorable conditions for the access of food materials and the equally rapid development of all the daughter and granddaughter cells, thus giving them an equal start as embryo-sac cells. The embryo-sac cell which finds itself in the most favorable position as regards the micropylar canal then commences a more rapid development, which takes place at the expense of the remaining megaspores. In the prophases of the third and succeeding divisions the chromosomes are about twice as long as those in the second division, the fibers are usually attached at about their middle point, where they are bent at a slight angle; the angle is directed toward the center of the spindle (*pl. 11, figs. 27, 30*). This division conforms, therefore, to the ordinary vegetative or typical division, differing only in the possession of the reduced number of chromosomes, which have been determined to be in *Crucianella* ten. It is not necessary for our present purpose to describe the remaining divisions in detail, more than to say that they fully correspond in character to the third.

The embryo-sac divisions in *Asperula* were not studied.

SUMMARY AND CONCLUSIONS

1. During the growth of the embryo-sac-mother-cell before the first division a large number of coarse fibers are present in the cytoplasm which persist through diakinesis of the first division. These are, in part at least, continuous with the circumnuclear complex of fibers preceding the formation of the spindle, and do not result from a rearrangement of the cytoplasmic reticulum. Further it is suggested that they be interpreted as currents of kinoplasm (hyaloplasm) corresponding to the radiations described by Wilson as occurring in the sea-urchin egg.

2. The spindle in both pollen- and embryo-sac-mother-cell is of multipolar origin. The nucleus is at first surrounded by a feltwork of curved tangentially placed fibers which gradually segregate into conical groups. By fusion of these groups a bipolar spindle is formed.

3. Centrosomes or centrosome-like bodies are not present. The poles of the spindle are finely tapering points with various topographic relations described in the body of the text. The suggestion made by Meves, prompted by his observations on *Paludina*, is not pertinent.

Under certain conditions, as for example in the pollen-mother-cell, where the proportions of the cell are not too great relatively to the size of the nucleus, the spindle ends find an insertion in the ectoplasm. At the point of insertion a small thickening may frequently be seen, and from this point run out radially placed, branching fibers in the ectoplasm. It is suggested that these are currents in the ectoplasm and may represent kinoplasm passing from the spindle into the ectoplasm during anaphase.

4. At the end of the first and second embryo-sac-mother-cell divisions, and at the end of the third division also when such occurs, as is generally the case in *Crucianella*, a system of connecting fibers arises without, however, the formation of cell walls. The megaspores and their derivatives in *Crucianella* remain in a syncytial condition.

5. A reduced number of chromosomes appears in the prophase of the first division of the pollen- and embryo-sac-mother-cells; in *Crucianella* this number is ten; in *Asperula* twelve. These numbers are maintained throughout the subsequent divisions.

The prophase of this division is characterized by the stage known as diakinesis. The metaphase offers on the whole the same characters as have been described by a number of authors for various plants and differs from them only in points of detail referable to the proportions of the chromosomes. The frequently difficult observation of the so-called ring form of the chromosome pairs in metaphase is a case in point. When the chromosomes are relatively more slender, as in the Liliaceae, the appearances are relatively more distinct. In many other plants they are less so on account of the extreme shortness and thickness of the chromosomes.

The second splitting of the chromosomes is longitudinal, and takes place in *Asperula* during the late anaphase of the first division. In *Crucianella* a similar splitting of the chromosomes takes place in the telophase of the first division and is here also longitudinal.

The first division in these plants is therefore heterotypic, in the sense of Flemming and Strasburger, and the second is homotypic, and results merely in the separation of the granddaughter rods already formed. The individuality of these bodies is, however, lost, so far as can be seen, in the resting nucleus preparatory to the second mitosis by fusion of the rods and by more or less complete diffusion of the chromatin.

It is concluded from this evidence that the divisions described are true tetrad divisions, and the four resultant cells as spores. It has on several occasions been urged that the position of these cells in the nucellus of angiosperms speaks against this interpretation, but it is not surprising that such an arrangement should occur in the ovule when we remember that the position of the spindle and through the spindle often of the cell wall is determined by growth, and that the growth of the sporogenous tissues is conditioned by a very different sort of environment from that found in the sporangium of the pteridophyta.

But the evidence is fast accumulating to show that it really frequently happens that the divisions are not such as to produce a single row of cells. This evidence has recently been collated by Max Koernicke * to which may be added the cases recorded by G. M. Holferty † as occurring in *Potamogeton*.

Adding to the above the facts derived from a cytological study of the divisions themselves, I fail to see the cogency of the statement made by Atkinson ‡ that the embryo-sac of the angiosperms "arises directly from the nucellar (sporangial) tissues or from the archesporium, without the intervention of spores." That the spores in many forms are losing or have already lost their physiological identity as spores is indeed true, but it is certainly a most remarkable fact that cannot be brushed aside that in the most extreme cases *Lilium* for example, the process of giving rise to these, cells is identical in all essential respects, to the process in all other plants, both pteridophyta and spermatophyta, in which this point has received careful study.

* Studien an Embryo sac Mutterzellen. (*l. c.*)

† Ovule and Embryo of *Potamogeton natans*. Bot. Gaz. 13 : 339. 1901.

‡ On the Homologies and probable Origin of the Embryo-sac. Science, II. 13 : 530. 1901.

On similar grounds the failure of the megaspores to form cell walls might be urged against the interpretation of these cells as such, but here again this character has dropped out without, it seems to me, invalidating the view that the cells in question are spores which are thereby removed one step further from their more primitive condition in which a cell wall was eminently necessary.

To be sure we are not rid of the conclusion that, in those plants in which the embryo-sac arises directly from the mother-cell the embryo-sac is constructed, so to speak, of four spores; or that, when the mother-cell suffers one division giving rise to two daughter-cells of which one only is functional, the embryo-sac is constructed of two spores. But after all, spores, in the sense here meant, are equivalent vegetative cells of a somewhat special sort, but with no necessarily separate existence, teleologically speaking, except in those plants in which the spores are the functional equivalent of the seeds in the higher plants.

The conclusion is therefore drawn that the cells under discussion are distinguishable by their origin, that they are not cut out of the cycle of development and that their morphological persistence is connected with the function of the mitoses; while on the other hand, the spore "*as such* * * * is wanting" * because the particular features of specialization which characterize spores have been lost in connection with the loss of the more primitive spore function.

The following question is very naturally raised at this point, namely, at what point in the life cycle does the gametophyte commence its existence.† There can of course be no categorical, or at least no final answer given under our present understanding. But we may state as fairly in accord with the facts, that the morphological identity of the gametophyte has been reduced along with the change in the function of the spores, and the two periods of development have been merged into each other, to different degrees in different plants. In the most extreme cases, as *Lilium*, the gametophyte appears to commence histologically with the embryo-

* Atkinson, *l. c.* The italics are his.

† Coulter and Chamberlain in their recently published volume "Morphology of the Spermatophytes" (New York, 1901), take a tentative position. In their accounts they "close the history of the sporophyte with the appearance of the spore mother-cell," since it seemed to them "to be the best defined line of demarkation" (page iv).

sac-mother-cell. Against the adoption of such an interpretation it may be urged that, where each of four spores form the primordium potentially or actually of an embryo-sac, the gametophyte becomes spilt up into four individuals. To be sure there are analogies to come to our aid, such as the constant development of four embryos from a single proembryo or the much more widely distributed phenomena of vegetative reproduction.

But in spite of these analogies, it would seem more natural to regard the gametophyte as *an individual by coalescence*, having its origin in four like vegetative cells whose primitive function has been lost. These four cells become grafted on each other, so to speak. The chief difficulty seems to be due to our formal conceptional idea of an individual, which in nature, outside of our consciousness, does not exist.

In comparison with the cases at present before us we may recall the very important results obtained by Juel * and by Murbeck.†

Juel found that in *Antennaria dioica* a tetrad division takes place, and his account of the process differs in no essential detail from mine. In *Antennaria alpina*, however, in which parthenogenesis is now known to obtain, the tetrad division does not occur, and the embryo-sac-mother-cell develops directly into the embryo-sac without any reduction in the number of the chromosomes or the usual chromosome-ring formation. Nor is this process to be compared with that in some plants in which megaspores are not delimited in the usual manner, but in which parthenogenesis does not occur (*Lilium*). In such plants the first two divisions are the same in character as the two divisions occurring when four megaspores are formed.

In *Alchemilla*, as shown by Murbeck, parthenogenesis also occurs, and in such event the megaspore mother-cell divides somewhat irregularly, forming at most three cells, because of the failure of one of the daughter-cells to divide. These divisions are not different in character from ordinary divisions; or, in other words, the heterotypic and homotypic divisions fail, and the chromosome number remains constant.

* Vergleichende Untersuchungen über typische und parthenogenetische Fortpflanzung bei der Gattung *Antennaria*. K. Sv. Vet. Akad. Handl. 33: No. 5. 1900.

† Parthenogenetische Embryobildung in der Gattung *Alchemilla*. Acta Reg. Soc. Physiogr. Lund. 11: No. 7. 1901.

In the light of the discovery of the fact that true tetrad mitoses do not occur in parthenogenetically reproduced plants * we are more than ever forced to insist upon the conclusions stated previously, that, in such plants as certain Liliaceae, the condition must not be interpreted as a suspension of spore formation, but as a reduction in the ontogeny of the gametophyte correlated with a loss of the spore function, without a loss of the morphological character of the spores so far as their development, as indicated by their mitoses, is concerned. The failure of true tetrad divisions in *Alchemil'a* and *Antennaria* is a notable exception which proves the rule.

The peculiarities characteristic of the tetrad divisions are now known to occur in so many plants that we may well pause to estimate their morphological significance, apart from the relation they hold to the maintenance of a constant number of chromosomes.

In general acceptation the term archesporium has signified a cell or cell aggregate from which the spore mother-cells are developed, as first defined by Goebel.†

These cells cannot, however, be distinguished from vegetative cells except by the fact that they are richer in food and plasmic content—they have the character of embryonic cells. According to their period of growth and the number of divisions they undergo their derivatives, the spore mother-cells (taken collectively the sporogenous tissue), are few or many. Now the cells of the sporogenous tissue are different from all other cells in the life cycle in that they always suffer tetrad division, and thereby exhibit very constant morphological characters which raise them to special morphological rank. This cell, or tissue, as the case may be, by virtue of the special character attaching to it, demands special recognition in terminology, and it would seem both natural and justifiable to regard it as constituting the archesporium. The use of the term in this way seems to me simple and unmistakable.

6. The third and following divisions are typical, and the reduced number of chromosomes is preserved.

In *Crucianella* all of the four megaspores in a given series may

* Juel (*l. c.*) interprets the phenomenon in *Antennaria alpina* as a special case of apogamy.

† Bot. Zeit. **38**: 545, 561. 1880; **39**: 681, 697, 713. 1881.

and often do develop further, and undergo a simultaneous division (the first embryo-sac division), from which the actual physiological and morphological equivalence is inferred.

THE BEHAVIOR OF THE POLLEN TUBE IN DIODIA AND RICHARDSONIA

(PLATE 15)

While engaged in the foregoing study of the embryology of certain Rubiaceae, namely, *Diodia teres*, *Diodia Virginiana* and *Richardsonia pilosa*, some conditions of rather more than usual interest attaching to the behavior of the pollen tube in these forms were met with. In view of the attention which the subject has of late received in some quarters—attention which has not by any means been barren of important results—it seems well at this time to present the outcome of a closer study of the phenomena in the above-mentioned plants, although the general subject in the Rubiaceae promises as a reward of future investigation further results of interest.

The flower in both genera presents the same chief features in common. The differences are chargeable to the different numerical relations in them, *Diodia* having a bicarpellary and *Richardsonia* a tricarpellary ovary. This fact having been mentioned, we shall from this time on ignore it, since it has no bearing in particular upon the following description and for the sake of simplicity we shall take *Diodia* as the type.

MORPHOLOGICAL RELATIONS OF THE STYLE

The locules of the inferior ovary are separated by a partition of two portions, distinct in origin and in anatomical structure. The lower portion, or basal element, arises as a ridge from the floor of the ovary, and inserted on its margin are the ovules, one in each locule. This basal element reaches to somewhat less than one-half the depth of the ovary. The remaining distance is occupied by a partition—the roof element—derived from the styles which growing out laterally from the upper part of the hollowed-out receptacles join at the middle point and grow upwards and downwards to form the style. This consists therefore of two (*Diodia*) or three (*Richardsonia*) concrescent elements. The roof and floor

elements of the ovarial partition fuse at their point of meeting and so complete the separation of the originally single ovarial chamber into locules.

HISTOLOGY

When the parts above described are young, the cells are, of course, uniformly isodiametric. After all the primordia are laid down, and the period of rapid growth prior to the assumption of the definitive form sets in, the relative rapidity of growth of the several organs is accompanied by changes in the proportions of the component cells. At about the time of fertilization the histological features are as follows.

The basal element of the ovarial partition consist of thin-walled parenchyma whose elements are slightly elongated in the direction of the flower axis and contain the vascular tissue which supplies the ovules. Where the stylar portion of the partition abuts against the basal elements, the cells of the latter are flattened out transversely, this being due partly to the pressure and partly to the mode of growth. The epidermis of the basal element of the partition has, at this point, very much thickened walls. The thickening commences in the outer walls (*fig. 1*) and extends at the period of fertilization to the lateral, but not to the basal walls (*fig. 5*). At the same time the regularity of the layer of cells is lost in the process of fusion which takes place between the basal and the stylar elements of the partition.

The stylar portion of the partition is composed at the time of fertilization of three distinct tissues. The innermost of these, or that lying in the axis of the compound style, and that with which we are here concerned constitutes a conductive tissue and is composed of elongated narrow cells with transverse or slightly oblique end walls and no intercellular spaces. These cells may be further distinguished from the surrounding tissues by their denser cytoplasmic content, and thicker, more deeply staining walls. Capus (**2**) has noted that the cells of the conductive tissue in the plants studied by him have thickened walls (collenchyma), but in *Alchemilla arvensis* according to Murbeck (**10**) no such thickening is present in any part of the course of the conducting tissue, a condition which is found in the free portion of the style of the plants under consideration. Here the cells are longer than in the stylar

partition, have thin walls with somewhat thinner cytoplasm, but no intercellular spaces. The conductive tissue is readily recognized in the style proper by the smaller transverse diameters of its cells. The change from this thin-walled tissue to the thick-walled is quite abrupt and takes place at the level of the roof of the ovary.

At the lower extremity of the style, at the point namely where it fuses with the basal partition, the conductive tissue suddenly expands from being long and narrow, to short, irregular and isodiametric. There is also an evident increase in the thickness of the cell-walls. The line of fusion which may be recognized easily in the young condition as represented in *fig. 1* is now so irregular as to be of itself unobservable. This irregularity and confusion of cells appears to be due to the thickening and partial gelatinization of the cell-walls or more especially of the middle lamella, for one may notice in sections that irregular lines of separation occur between the cells, thus indicating their loose relations. Such changes have been noted, also, by Capus (**2**) although according to him such changes are much more pronounced in the style and stigma So far as the writer's observation goes such pronounced changes do not occur in the upper portion of the style, although here the walls are a little thickened, and that they are on the more and more pronounced the deeper one penetrates the whole style.

At this point of fusion, as described in the previous paragraph, the ovules, two in *Diodia*, three in *Richardsonia*, are inserted upon the edge of the basal partition. The epidermis above described as undergoing a thickening of its walls is continuous with the epidermis of the ovules, a description of which is necessary at this point.

The ovule is, broadly speaking, anatropous, and possesses, in addition to the single integument characteristic of the gamopetalae, a second outgrowth, the origin of which has been elsewhere described (p. 53) as a secondary enlargement of the funicle, a sort of strophiole. A profile view of this organ, as seen in *Diodia teres*, is shown in text *fig. 1*, and as seen in *Richardsonia* in *fig. 9*. A striking feature of this organ with which we are at present concerned is the profound modification of the epidermis to form a special con-

ductive tissue for the pollen tubes. When young the cells of this tissue are of an approximately cubical or columnar form (*fig. 1*) with thin walls. As the ovule develops they change into deep columnar cells with thick walls excepting at their inner ends (*fig. 5*), where the basal and lateral walls for a little distance are thin. The contents of these cells are more dense than those of the deeper lying cells and the cytoplasm is very finely granular. Their nuclei are large with very finely divided chromatin. These cells appear to correspond in general with the cells described by Capus (2) as occurring at the base of the funicle in *Dracaena elegans* and by Dalmer (3) in the placenta of *Mahonia aquifolium*. From those in *Dracaena*, however, the cells in *Diodia teres* and *Richardsonia* differ in having thick walls, and from those in *Mahonia* in the fact that they do not secrete the mucilage which, according to Dalmer, serves as food for the pollen tube. They are not glandular cells, but, strictly speaking, cells of a conductive tissue as is shown by the behavior of the pollen tube towards it. With reference to the strophiole it may be remarked that this organ is present in other members of the same family, but that, so far as known, in no other is such a special tissue present, excepting as we shall see beyond in *Diodia Virginiana*. On the upper side of the funicle these cells have somewhat different dimensions from, but otherwise are exactly like those of the lower side where they have the longest ongitudinal diameter (*text figs. 8 and 9*). Here the strophiole lies against the ovules so as completely to close the micropyle. It will be seen that there is thus formed a collar of columnar epidermis which is continuous around both sides of the funicle and, as will be shown, completes the path of the conductive tissue from the style to the micropyle.

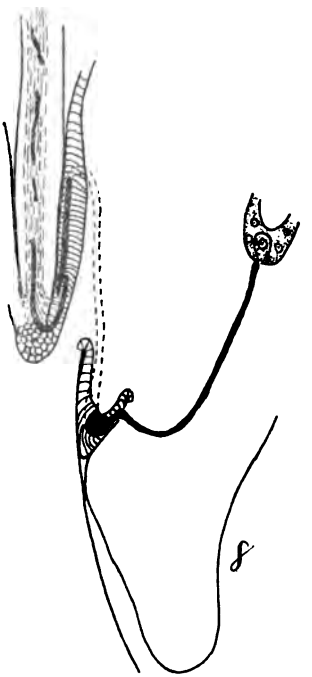

FIG. 8. Part of ovule and stylar tissue of *Diodia teres*, showing the path of the pollen tube.

THE COURSE OF THE POLLEN TUBE

In the free upper portion of the style the cells of the conductive tissue are, as above pointed out, long and very narrow. Through this tissue the pollen tube takes a somewhat devious, though on the whole direct course (*fig. 2*), and as the tube has a transverse diameter much greater than that of the neighboring conductive tissue cells, one would expect that the mechanical pressure alone would cause not a little disturbance in the conductive tissue. Such, however is not the case. The pollen tube does not destroy the cells among which it passes either by chemical influences, such as digestion, or mechanically. It is true that the cells are frequently disturbed in position, as is plentifully evidenced by the form of the nuclei when the pollen tube happens to exert pressure on a cell in such a way as to affect its nucleus (*fig. 3*). Without exception, however, the nuclei and cytoplasm stain perfectly normally and evenly. The walls of the pollen tubes are to a considerable degrees thicker than those of conducting cells, while the cytoplasm of the former is more coarsely granular than that of the latter.

When the pollen tube reaches the stylar partition it meets with conductive cells with thicker walls and of larger transverse dimensions. The nuclei are here long-oval in form. Here the path has about the same character as in the free part of the style. Occasionally one finds a sharp turn such as is shown in *fig. 3*, which represents a small part of the conductive tissue in longitudinal section showing a pollen tube cut transversely. A study of this preparation shows clearly that the effect of the pollen tube upon the tissue in this part of its course through which it passes is mechanical. Instances are frequently found in which the pollen tube passes athwart the conductive tissue, either directly or more or less obliquely. At first glance it is somewhat difficult to attribute such behavior on the part of the pollen tube to mechanical influences. When, however, we reflect upon the extreme sensitiveness of the protoplasm of the pollen tube to stimuli, it becomes less difficult. The impingement of the end of the pollen tube upon the end wall of a cell is, we believe, enough to turn it out of its direct path. Upon approaching the point of fusion of the basal and roof elements of the ovary septum the pollen tube

meets with cells of similar histological characters as those of the cells through which it has immediately passed, save in dimensions and in the mucilaginous condition of the inner lamella. Here they are irregular and isodiametric as above stated, and are derived in part from each element of the septum. Through this mass of tissue the pollen tube takes a more irregular course, showing some tendency to branch, and passes from the stylar tissue into the upper part of the basal septum, into, therefore, the epidermis above described as continuous with the columnar epidermis of the

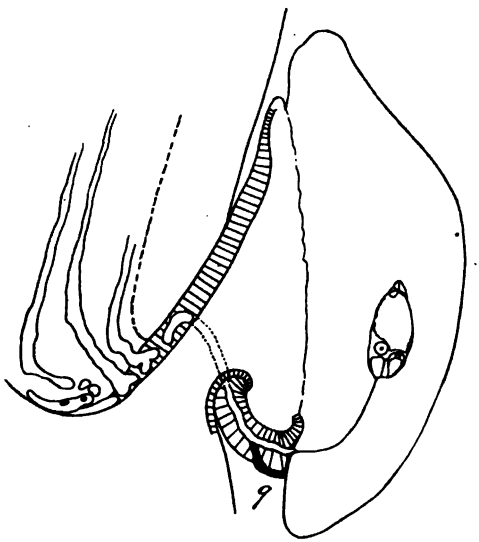

FIG. 9. Ovule and part of the stylar tissue of *Richardsonia pilosa*, showing path of the pollen tubes.

strophiole. Upon meeting with the ordinary thin-walled parenchyma of this, the tube abruptly turns at right angles to its former course (*text fig. 9*). In no case does the tube penetrate beyond the thick-walled fusion cells further than to basal septum. The contents of the pollen tube may be seen well in the lower region of the style. In properly stained preparations the generative nuclei have been repeatedly found. The vegetative nucleus, however, has not been seen in this region. The cytoplasm is densely and finely granular, entirely filling the tube, while in the older parts of the same only a thin granular layer may be discerned on the wall, or none at all.

In this part of its course the pollen tubes which are usually to be found in numbers produce a destructive effect upon the cells, upon which they impinge. The effect has the appearance of being due to mechanical pressure owing in part to the number of tubes present, and in part to their larger diameter. The contents of the conductive cells thus affected appear homogeneous and deeply staining and the nuclei lose their normal appearance, while the cells are crushed out of shape (*fig. 4*). The effect of the tube is unequal, destroying cells, now here, now there, without any dissolution of the walls, showing at once the difference between a mechanical operation, and one involving the histolysis of the circumjacent tissue as by digestion.

The behavior of the pollen tubes when they reach the subepidermal parenchyma of the basal partition is quite uniform, and is strongly suggestive of a purely mechanical influence. In the case of *Richardsonia* there is formed at that point by virtue of the confluence of the funicles of the three ovules, a basin so to speak, filled with the isodiametric irregular conductive cells. Should we plant a seedling in a basin of soil the roots would penetrate till the walls of the basin had been reached, and they would then glide along the walls. Such a case appears to be quite analogous to the one before us, excepting that geotropism plays no part in the behavior of the pollen tube. In *Diodia teres* the penetration of the epidermis of the basal partition does not take place as in *Richardsonia;* but rather the tubes bend upward in the irregular cells of the stylar conductive tissue, passing at first between the walls of the style and strophiole, but soon penetrating the columnar epidermis of the latter (*text fig. 8*).

Having now reached the thick-walled epidermis, the pollen tube travels along till it enters the regular thick-walled columnar cells which constitute the collar of connective tissue about the funicle and the strophiole. It then passes out of the fusion tissue and travels in a fairly direct path upwards, that is toward the chalazal region of the ovule (*text figs. 8 and 9*). It gradually turns, however, so as to pass around one side or the other of the funicle, and then finds itself in the epidermis of the lower side of that organ. At this time the course is more or less irregular, and the pollen tube sometimes branches (*fig. 7*). Occasionally in the

region of the micropyle it passes beyond the surface of the epithelium (*fig. 6*). It then glides along the surface a short distance and then passes between the conductive epidermis and the integument (*text fig. 1*). Ultimately it finds the micropyle and travels along it to the embryo-sac.

Two points of importance are to be noted at this point, the entirely or almost entirely intercellular path of the pollen tube, and the direction of its path which is not in the direction of least resistance, but at right angles to the longtudinal axis of the cells of the conducting tissue.

During this part of its course, that is, as it is passing through the fusion tissue and the strophiolar conductive tissue, the pollen tube as above pointed out not infrequently branches (*fig. 7*). Nawaschin has noted a similar tendency on the part of pollen tubes in the Birch (**11**, p. 22), to branch "wo das betreffende gewebe keine deutliche Anordnung seiner Zellen in longitudinalen Reihen aufweist." When in the strophiolar conductive tissue, the pollen tube shows more or less inability to pursue a path which is constantly at right angles to the component cells. It may then slip out to the surface. This happens most frequently in *Richardsonia* in the neighborhood of the micropyle where there is little or no pressure exerted upon the strophiole by the adjacent structures. In *Diodia teres* where the strophiole in the micropylar region is tightly wedged between the ovule and the wall of the ovary, the pollen tubes take constantly a deeper course (*text fig. 8*). These phenomena lead to the suggestion that the cause which has brought about the habit of intercellular growth in the pollen tube is a mechanical one, and this factor may probably be called upon to account for the behavior of the pollen tube in many forms. We have in mind such cases as occur, for example, in the Cannabinaceae of which Zinger (**23**) has given an account. According to this author, the intercellular node of growth is of phylogenetic significance, and, by means of such interpretation, brings his view into line with that of Nawaschin, who has vigorously supported the contention that the behavior of the pollen tube in the Amentiferae is inherited from their ancestral forms, and has endeavored, on this theory, to connect the lower Angiosperms with the Gymnosperms A discussion of this question is not pertinent here, but it may be

said in passing that recently Murbeck (10) has, we believe, successfully, contested the view of Nawaschin. I believe that a study of the facts in a larger number of plants will lead to a more general recognition of the principle laid down by Murbeck (10) in the words, "Der intercellulare Wachstumsmodus des Pollenschlauches ist als eine physiologische Eigenthümlichkeit zu bezeichnen, * * *" and of the *mechanical conditions* as constituting not the least important factors in leading to such behavior. As a further illustration of peculiar mechanical conditions I would cite the instance of *Cynomorium* in which, as shown by Pirotta and Longo (18), the micropyle is completely closed and there appears in its place a cone of conductive tissue through which the pollen tube must penetrate. Zinger (21) has shown somewhat similar relations in *Cannabis*.

When, as shown above, the pollen tube passes to the surface, it travels a short distance along the conductive tissue, soon finding its way between the strophiole and the integument. Under such circumstances the wall of the pollen tube may well be seen (*fig. 6*).

The effect of the pollen tubes upon the cells of the collar of conductive tissue appears to be purely mechanical, as in the case of that in the style. Forcing its way between the cells, the pollen tube causes in them but little or no distortion and, so far as I have observed, no destruction (*figs. 5, 6*). It would appear that, although the cells of the conductive tissue form a true tissue, and are not crowded papillae, their thickened walls are nevertheless not bound together firmly but rather are loosely related by a soft, mucilaginous middle lamella.

Having reached the micropyle, the pollen tube now passes into the micropylar canal. The cells lining the latter are characterized by somewhat thicker, more deeply staining walls than those of the other integumental cells. The pollen tube eventually reaches the synergids. In the plants under discussion these cells have the "hyaline, striated tips," as described by Strasburger (21), extremely well developed. The generally accepted view that the synergids serve as a conductive apparatus is strengthened by the analogy which I venture to believe exists between their curious cellulose tips and the thickened and partially gelatinized cell walls of the conductive tissue.

Diodia Virginiana

In this species the conductive tissue is of a somewhat different character from that in the two plants already discussed. In the style both above and below the roof of the ovary the cells are cylindrical, their transverse walls being transverse, though occasionally oblique in varying degrees. The nuclei are not so much elongated, and correspondingly the length of the cells is not so great. The cell walls are thin throughout the whole range of stylar conductive tissue, excepting near the region of fusion of the basal and stylar parts of the partition where a slight thickening of the walls occurs. The conformation of the stylar conductive tissues is the same as in the other species.

In the character of the conductive tissue of the ovule, however, lies the greatest difference, a difference which, as we shall see, is connected with the behavior of the pollen tube. The tissue is disposed on the strophiole in a band around the insertion of the funicle, and extending downwards towards the micropylar region. The accompanying text figure 10 shows in a schematic way the arrangement. The component epithelial cells are approximately cubical in form (*fig. 8*), are fairly richly supplied with cytoplasm, and have a large nucleus. The outer walls are thickened, and exactly correspond in all respects to the homologous tissue in the other species studied in the young condition, before any further changes take place, *i. e.*, before the cell elongates into columnar form. At the time of pollination, a mucilaginous secretion appears so that at this time there lies on the surface of the conductive tissue a layer of mucilage of a thickness of nearly half the depth of the cells. The mucilage may be traced between the cells to some depth.

This conductive tissue corresponds in general to that which has been described by Dalmer (3) as occurring on the placenta in certain Liliaceae both in form and in the occurrence of the mucilaginous secretion through which that author has shown that the pollen tubes grow, and from which they derive nutrition which enables them to grow onward toward the micropyle. Apparently similar cells have been described by Lang (5) in *Byblis* and *Polypompholyx.*

The course of the pollen tube through the style needs no remark since what has been said above applies throughout. One point, however, needs mention, namely, that here the cellulose plugs described by Treub (**22**) as occurring in the pollen tubes in *Casuarina*, by Nawaschin (**12, 16**) in the Amentiferae and by Murbeck (**10**) in *Alchemilla* are here very easily and clearly seen. Two of these plugs are shown in *figs. 10 and 11*. It will be seen from the outline of the plug and the form of the somewhat shrunken pollen tube contents that these fit each other. One finds sometimes that the tube on one side of the plug is empty (*fig. 10*). In other cases cytoplasm occurs in both sides (*fig. 11*). Similar plugs occur lower down in the fusion tissue, but they have not been observed elsewhere.

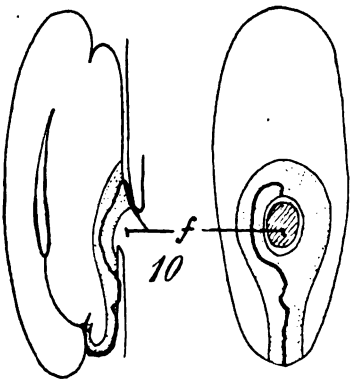

FIG. 10. Two views of the ovule of *Diodia Virginiana*, showing the conductive epidermis (dotted) and the path of the pollen tube; *f*, funicle. (*Schematic.*)

When the pollen tube reaches the epidermis of the basal partition (*text fig. 10*), it stops at that point, and does not enter between the cells as occurs in *Richardsonia*. They then bend upward and travel between the two tissue masses until they come to the collar of conductive epidermis of the strophiole, in the mucilaginous outer wall of which they pursue their way. After moving upward, *i. e.*, toward the chalaza, a little distance, they turn, following the band of secreting epidermis as shown in *text fig. 10*, and being completely buried in the mucilage, as occurs in plants studied by Dalmer (**3**). The behavior of the pollen tube toward the walls of the secreting cells needs particular mention in view of the fact that the wall of the former coalesces with the outer walls of the latter in such a way as to be completely indistinguishable. In one preparation the pollen tube was cut transversely at one point of its course and showed this relation especially well. In *fig. 9* this is well shown, from which it will be seen that the outer part of the tube wall is thin, thickening markedly on the sides nearer the epi-

dermis, and, as above said, coalescing with its outer wall. It is not clear, however, whether the pollen tube wall as represented, and as it appears to the eye in the preparation belongs, properly speaking, entirely to the pollen tube. At any rate the soft character of the walls and their coalescence makes the determination of this point difficult.

When the pollen tube reaches the lower end of the strophiole, it travels, as before, superficially around and into the rift between this and the integument. This rift is filled with the slimy secretion derived entirely from the epidermis of the strophiole, inasmuch as the epidermis of the integument is not secretory. In this way the micropyle is at last reached and entered.

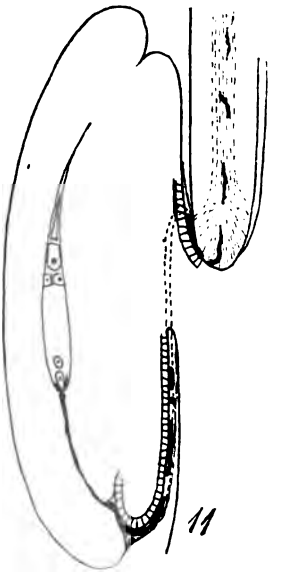

FIG. 11. *Diodia Virginiana*. Ovule and portion of the style, showing the path of the pollen tube.

If now we compare the three types described as regards the development of the strophiolar conductive tissue, and the behavior of the pollen tube, we may accordingly arrange them into a series in the following order and with the characters indicated.

1. *Diodia Virginiana*.—The conductive tissue consists of epidermal cubical cells with thickened outer walls covered with a mucilage secreted by them. The mechanical relations of the ovary are such that the pollen tubes may easily lie between the strophiole and the ovary wall. The pollen tube travels *superficially* along the funiculus and strophiolar conductive tissue, but imbedded in the mucilaginous secretion.

2. *Diodia teres*.—The conductive tissues consists of columnar epithelial cells with thickened outer and lateral walls. The middle lamella is mucilaginous. There is no secretion on the outer surface. The mechanical relations are such that the strophiolar conductive tissue is compressed between the ovule and ovary wall. The pollen tube enters the said conductive tissue immediately on commencing its upward movement along the funicle and remains within till it reaches the micropyle.

3. *Richardsonia pilosa.*—The conductive tissue as in *Diodia teres*, but somewhat different histological relations exist in the fusion tissue of the ovary septum. The mechanical relations are such that the strophiolar conductive tissue above the funicle is compressed between the ovary wall and the ovule. Below, *i. e.*, toward the micropyle, the pressure is reduced. The pollen tube enters the conductive tissue at the base of the stylar portion of the partition, travels by the intercellular method in the same till it reaches the micropylar region where it often though not always bends towards the surface.

The above-named facts speak for the mechanical conditions in the ovary as important factors in determining the course of the pollen tube, whether intercellular or not.

In review the following results and conclusions are presented:

1. In *Richardsonia pilosa* and *Diodia teres* the course of the pollen-tube is chiefly intercellular, a phenomenon clearly secondary in view of the fact that in a closely related species, *Diodia Virginiana*, the pollen tube pursues its path freely in the ovary cavity in that part of its course.

An important factor in determining such behavior of the pollen tube is found in the mechanical relations (pressure) existing between the ovule and the ovary wall. This is added as evidence supporting the contention of Murbeck to the effect that the intercellular mode of growth of the pollen tube is a matter of physiological meaning.

Inasmuch as such a difference in the behavior of the pollen-tube as has been pointed out may occur between two closely related species of the same genus, I infer, contrary to the view of Nawaschin, that the behavior of the pollen tube is of very limited significance—indeed of no practical significance—from a phylogenetic viewpoint. The condition is analogous to that of the archesporium in the angiosperms, which occurs, so far as at present known, in eight genera of the Rosaceae and in a dozen others widely scattered through the whole range of forms from the Rubiaceae (**5, 6**) to *Casuarina.**

This statement does not preclude the possibility that Nawas-

* A summary of the facts and literature pertaining thereto will be found in papers by Murbeck and Koernicke already quoted.

chin's contention, that the primitive behavior of the pollen-tube was entirely intercellular, is true.

2. The conductive tissue of the style consists of: (1) very thin-walled cylindrical cells in the upper part and (2) thicker walled cells in the lower part. The latter pass from a cylindrical to an irregular isodiametric form in the fusion tissue, in which the middle lamella is evidently soft and yielding.

3. A conductive tissue is here described which is morphologically a part of the ovule, or, more exactly, a part of a peculiar secondary outgrowth which I have designated the strophiole. It takes two histological forms: (1) In *Diodia Virginiana* it is composed of cubical, mucilage secreting cells, with thickened outer walls, corresponding to analogous cells found in many plants on the placenta. (2) In *Diodia teres* and *Richardsonia pilosa* the homologous tissue is composed of columnar, thick-walled cells (the thickening being absent from their bases only) with a soft middle lamella. No outer mucilage layer is here found.

In these plants we find a conductive tissue composed of elongate, regular cells, in which their longitudinal axes are placed at right angles to the intercellular path of the pollen tube for the direct passage of which this condition is mechanically less favorable than in the kind of conductive tissue in which the longitudinal axes of the component cells are parallel to the path of the pollen tube.

4. The pollen tube does not in general act unfavorably upon the cells with which it comes into contact. When however it does it may be referred to mechanical causes. This conclusion appears to accord with the observations of others.

5. The pollen tube shows a tendency to branch where the cells are irregular and isodiametric, or where the long axis of the conductive tissue cells are placed at right angles to the course of the pollen tube. This behavior speaks against the view of Miyoshi: "Im Griffel werden die Pollenschläuche wesentlich mechanisch zum Fruchtknoten gelenkt" (8).

6. There remains an undetermined factor in the guidance of the pollen tube. We cannot tell how the same is able to find its way to the egg in the definite way in which it does. The pollen tube is negatively aërotropic, and is chemotropic, as shown by

Molisch (9). These facts explain its behavior toward the stigma, but the later behavior in the conductive tissue remains unexplained. According to Molisch again, chemotropism "muss bei der Wanderung des pollenschlauches zur Eizelle, resp. bei der Auffindung derselben in vielen Fällen eine wichtige Rolle zufallen." But it is difficult to see how chemotropism can be an efficient factor unless there be a differential distribution of the stimulant. Miyoshi on the other hand, has maintained, in the words above quoted, that the operation is a purely mechanical one. Nawaschin (16), to whom we are indebted for a critical exposition of these two views, has pointed out that both presuppose that "der Pollenschlauch Reizbewegungen ungehindert ausführen könne," a condition which is found only where the pollen tubes have free space in which to move. If we assume that such are the conditions in *Diodia Virginiana*, in which the pollen tube moves freely in the ovarial cavity, what may we say of *Diodia teres* and *Richardsonia pilosa*, in which the pollen tube is not free to move in the ovarial cavity, but pursues an intercellular path, parallel to that which we may believe, from the case of *Diodia Virginiana*, it would take were the mechanical conditions favorable, and this in spite of the character of the conductive tissue which is mechanically unfavorable.

I believe that we may be justified in maintaining:

1. With Nawaschin, that the occurrence of a secreting conductive tissue speaks as much for the nutrition of the pollen tube as for the necessity of mechanical guidance; that, moreover, the ability of the pollen tube to secrete a cellulose-dissolving enzyme indicates the former, as in point of fact the pollen tube does not penetrate the cells of the conductive tissue; and that the assumption that in order to respond to a stimulus, the pollen tube must have unoccupied space in which to move is unnecessary and probably untrue.

2. With Molisch, that chemotropism is the important factor, and the guidance of the pollen tube; but that *the distribution of the stimulant in the conductive tissue is a differential one;* and, as Nawaschin (16) suggests, "die Verbreitung der Reizstoffe Kann zwischen den Papillen des Leitgewebes in Folge der capillarkräfte leicht zu Stande kommen," extending his statement, however, to cells as well as papillae.

The experiments of Miyoshi (8) by which he showed that pollen tubes will penetrate the cut end of a style and travel toward the stigma, and that when a lateral cut is made into the conductive tissue the pollen tubes will grow out in various directions, we maintain not only do not support his view that the pollen tubes are guided in a purely mechanical way, but also that they do not contradict the suggestion of such a differential distribution of an appropriate stimulant, inasmuch as a cut in the conductive tissue would in all probability set up disturbances by which the ordinary distribution of the stimulant might be reversed.

It may, of course, be that Miyoshi's contention is true for the style, although I believe that the case is not proven ; but that the pollen tube is guided in one way in one region of the conductive tissue, and in another way in another, seems quite improbable.

3. The suggestion is submitted that the synergidae are the source of the stimulant, and constitute the center of distribution of the stimulant. To this idea I am led by the cytological character of those cells, and by their position as the only effective center, exclusive of the egg itself. We do not forget the experiment of Strasburger (21) on *Torenia*, the results of which were, however, negative. Searching experimentation is still needed to throw light on the perplexing problem which we have attempted somewhat further to elucidate.

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Explanation of Plates

The letters in the following plates signify as follows:

ant., antipodal cell (or nucleus).
ar., archesporium.
c. epi., conductive epidermis.
e. s., embryo-sac.
n. c., nutritive cells of the chalaza.
p. t., pollen-tube.
s. p., strophiolar plate of brown cells.
s. t., strophiole.

PLATE 5. *Callipeltis cucullaria*

FIG. 1. An early stage in the growth of the nucellus. The archesporium is delimited and the periclinal divisions giving rise to the integument are to be seen.

FIG. 2. Older conditions of the nucellus in which the archesporial cells are approaching maturity.

FIG. 3. A nucellus cut tangentially showing a larger number of archespores than may be seen in a radial section.

FIG. 4. A radial longitudinal section through a mericarp. The formation of megaspores has been consummated and one especially large one may be seen before it has started to migrate. The micropylar canal is, therefore, intact.

FIG. 5. A group of megaspores in which one, the lowest one in the figure, has enlarged and is preparing for migration.

FIG. 6. The migrating megaspore may be seen lying in the micropylar canal, the endodermis of which has been destroyed by the activity of the moving cell.

FIG. 7. The final division of the embryo-sac cells to form the eight cells of the nearly mature condition of that organ.

FIG. 8. An instance in which two megaspores have migrated and have given rise to two imperfectly formed embryo-sacs.

FIG. 9. An embryo-sac after fertilization has taken place. The embryo is in the unicellular state and the endosperm nucleus is in its first division. The material derived from the disintegrating megaspore has completely disappeared.

PLATE 6.

FIGS. 1–12. *Callipeltis cucullaria.*

FIG. 1. Ovule in longitudinal section at the time of the migration of the embryo-sac-mother-cell, and before its division. The remains of the megaspore mass may still be seen.

FIG. 2. An example in which several megaspores have began migration. In this figure and in Fig. 1 may be seen the compressed endodermis

FIG. 3. Embryo-sac during fusion of the polar nuclei. The different cells have now taken on their definite form.

FIG. 4. Embryo-sac with one-celled embryo. One synergid remains intact.

FIG. 5. A still later condition with 11-celled embryo. Antipodals still intact.

FIGS. 6–9. Various embryos in various stages of development.

FIG. 10. Suspensor, showing perhaps its most extreme development in this species.

FIG. 11. Ovule with endosperm and embryo approaching maturity (seed condition). The endosperm cells which are still actively absorptive are drawn on the left side.

FIG. 12. Section through the pericarp (four cell layers), integument (one cell layer) and the outer cell layer of the endosperm.

FIGS. 13–23. *Sherardia arvensis.*

FIG. 13. Mass of megaspore mother-cells.

FIG. 14. Embryo-sac with the migrating embryo-sac-mother-cell.

FIG. 15. Definitive embryo-sac just previous to fertilization.

FIGS. 16, 17. Egg apparatus and fusing polar nuclei.

FIG. 18. Two-celled embryo with endosperm.

FIG. 19. Older embryo in which two regions in the suspensor are evident. The basal region produces haustoria.

FIG. 20. Shows a somewhat more developed condition of the embryo proper than that seen in *fig. 19.*

FIG. 21. Suspensor of nearly mature embryo. The basal part of the haustorium which lies embedded in the intact endosperm has degenerated. The haustoria of the part of the suspensor which lies in the digested endosperm are active.

FIG. 22. Ovule from which Fig. 21 is taken.

FIG. 23. Peripheral portion of endosperm showing outer absorbing cells.

PLATE 7. *Galium*

FIGS. 1, 2. *Galium Mollugo.* Two successive stages in the development of the nucellus.

FIG. 3. *Galium recurvum.* In this figure the archesporium has reached maturity and the integument has started its growth.

FIG. 4. *Galium recurvum.* A megaspore-mass just before the migration of the embryo-sac-mother-cell. The capping cells are not yet destroyed.

FIG. 5. The megaspore mother-cell in migration.

FIG. 6. *Galium Parisiense.* The two-celled stage of the embryo-sac.

FIG. 7. *Galium triflorum.* The embryo-sac. The same embryo-sac is shown in Fig. 9 in order to show the length of the long antipodal.

FIG. 8. *Galium Aparine.* An embryo-sac in which the endosperm has begun to form and in which the embryo is composed of six cells.

FIG. 9. *Galium triflorum.* Ovule in longitudinal section showing the proportions of the embryo-sac and the relative position of the end of the food-conducting tissue of the raphe.

FIG. 10. *Galium tinctorium.* The embryo-sac. The constriction of the endosperm cell and the irregular nucleus are to be seen.

FIG. 11. *Galium Mollugo.* Two embryo-sacs produced in the same ovule.

FIG. 14. *Galium Aparine.* Ovule with endosperm and young embryo. The remnants of the antipodals are still to be seen.

FIG. 13. *Galium Parisiense.* An embryo.

FIG. 12. *Galium Parisiense.* An embryo-sac. The embryo has begun its growth.

FIG. 15. The lower half of a mericarp of *Galium Mollugo.* The undigested walls of the cells lining the micropyle are to be seen at the end of the suspensor. *emb*, embryo; *end*, endosperm; *f*, funicle; *i*, integument; *p*, pericarp; *s. c*, stylar column.

PLATE 8. *Asperula*

FIG. 1. *Asperula azurea.* A nucellus in an incipient stage of development.

FIG. 2. *Asperula setosa.* The migrating megaspore.

FIG. 3. *Asperula azurea.* An embryo-sac. Here two antipodals attain a spherical form.

FIG. 4. A young embryo. In this form the suspensorial haustoria reach a high degree of development.

FIG. 5. *Asperula* sp. An embryo showing the extreme development reached by the suspensor in this form. The surrounding outline represents the limit of the endosperm.

FIG. 6. *A. azurea.* This figure illustrates the persistence of the suspensor till a late stage of embryonic growth.

FIG. 7. *A. galioides*—embryo-sac.

FIG. 8. *A. galioides.* A rather early stage in the development of the embryo. The haustoria are commencing to grow out into the endosperm.

FIG. 9. *A. galioides.* The suspensor of an embryo which has reached a still greater degree of maturity than that depicted in *fig. 6.*

PLATE 9. *Asperula montana*

FIG. 1. Pollen mother-cell nucleus in the stage of diakinesis.

FIG. 2, *a*, *b*, *c*, *d*, *e*. Chromosome pairs and rings from prophases of the nucleus of the pollen mother-cell.

FIG. 3. Pollen mother-cell, early anaphase of the first division.

FIG. 4. One pole of the spindle, the end of which is seen attached to the ectoplasm; from point of attachment are irregular radiating fibers to be seen.

FIG. 5, *a*, *b*, *c*. Chromosomes, early anaphase, first division (*p. m. c.*).

FIG. 6. Late anaphase; chromosome pairs shown on a larger scale in the following three figures:

FIGS. 7–9. Chromosome pairs from anaphase, first division (*p. m. c.*).

FIG. 10. End of spindle (anaphase, first division) attached by means of kinoplasm strand to the ectoplasm.

FIG. 11. Telophase, first division (*p. m. c.*).

FIGS. 12, 13. End of the first division—resting stage (*p. m. c.*).

FIG. 14, *a*, *b*. Chromosome pairs, telophase, first division.

FIG. 15, *a*, *b*, *c*, *d*. Chromosome pairs during metaphase of the second division.

FIG. 16. Pluripolar diarch spindle (second division, *p. m. c.*).

FIG. 17. Polar view of chromosomes (12) metaphase, second division.

FIG. 18. Anaphase, second division.

FIG. 19. Polar view anaphase, second division.

FIG. 20. Resting stage, end of second division.

FIG. 21, *a*, *b*. Chromosome pairs, prophase, first embryo-sac-mother-cell division.

FIG. 22. Early anaphase, first embryo-sac-mother-cell division.

FIG. 23. Telophase, first division, embryo-sac-mother-cell.

PLATE 10

FIGS. 1–6. *Rubia tinctoria*

FIG. 1. Young ovule before the integument has started to grow. Two archesporial cells are shown.

FIG. 2. Daughter-cells of megaspore mother-cell in division.

FIG. 3. Embryo-sac with four cells.

FIG. 4. Embryo-sac with two cells. At *e s* a second embryo-sac is seen containing but one nucleus. Above, in the archesporial cavity are several megaspore nuclei.

FIG. 5. Embryo-sac, definitive.

FIG. 6. Embryo. The embryo proper is very young, consisting of 13 cells. The suspensor is exceedingly well developed as a haustorial organ.

FIGS. 7–22. *Crucianella*

FIG. 7. *C. gilani a.* Young ovule, showing archesporium of very large cells, and the nutritive cells at the chalazal end.

FIG. 8. Daughter-cells, at close of first division.

FIG. 9. Megaspores formed by two divisions of the archesporial cells. The end cell has become the embryo-sac cell and has begun to develop as such.

FIG. 10. *C. herbacea.* Ovule, in outline, showing its typography. Chalazal nutritive tissue and megaspore masses above and an embryo-sac below, both partially surrounded by the specialized nutritive tissue derived from the integument.

FIG. 11. Megaspore masses (seen in *fig. 10*), enlarged.

FIG. 12. Embryo-sac (seen in *fig. 10*), enlarged. One antipodal nucleus only. Polar nuclei not yet fused.

FIG. 13. Nutritive integumental tissue from another ovule; archesporium and chalazal nutritive cells above; embryo-sac below.

FIG. 14. A trinucleate cell from integumental nutritive tissue.

FIG. 15. Embryo showing, in particular, the suspensor.

FIGS. 16–22. *Crucianella macrostachya*

FIG. 16. Two embryo-sac-mother-cells. The one on the right with a spindle of the first division; on the left two spindles of the second division.

FIG. 17. Anaphase and telophase of the second division.

FIG. 18. Anaphase and telophase of a third division.

FIG. 19. Quadrinucleate embryo-sac, and three disintegrating megaspores.

FIG. 20. Eight nuclei derived from four megaspores.

FIG. 21. Nuclei (four) of an embryo-sac in mitosis. The uppermost spindle in the figure is a megaspore in mitosis.

FIG. 22. An embryo-sac (with two nuclei) and four sets of megaspores. Those of one set are in mitosis.

PLATE II

FIGS. 1–31. *Crucianella gilanica*

FIG. 1–13. Pollen tetrad divisions.

FIG. 1. Chromosome pairs seen during prophase of the first division.

FIG. 2. Anaphase of the first division; the chromosomes are in various stages of separation.

FIG. 3. The forms assumed by separating daughter chromosomes.

FIG. 4. Daughter chromosomes in later anaphase.

FIG. 5. Chromosome pairs in telophase of the first division.

FIG. 6. End of first division.

FIG. 7. Chromosome pairs as seen in metaphase of the second division.

FIG. 8. Metaphase, second division.

FIG. 9. Late anaphase, second division.

FIG. 10. Anaphase, second division, spindle showing its connection with the ectoplasm.

FIG. 11. Equatorial plate, polar view; ten chromosomes.

FIG. 12. Equatorial plate, polar view; eleven chromosomes.

FIG. 13. End of second division. Drawn to the same scale as *fig. 6*, for comparison of the size of nuclei.

FIGS. 14–25. Embryo-sac tetrad divisions.

FIG. 14. Diakinesis.

FIG. 15. Condensation of rings, the aster-like radiations correspond to those seen in Fig. 42.

FIGS. 16, 17. Anaphases, first division.

FIG. 18, a–g. Forms assumed by the chromosomes during anaphase of the first division.

FIG. 19. Telophase, first division.

FIG. 20. Telophase, first division.

FIG. 21. Prophase, second division

FIG. 22. Metaphase, second division.

FIG. 23. Chromosome pairs, metaphase, second division.

FIG. 24. Anaphase, second division.

FIG. 25. Chromosomes, anaphase, second division.

FIG. 26. Chromosomes, anaphase, first division.

FIGS. 27–30. Embryo-sac divisions.

FIG. 27. First embryo-sac division, in metaphase.

FIG. 28. Second embryo-sac division, polar view.

FIG. 29. Chromosome pairs, second embryo-sac division.

FIG. 30. Fourth (antipodal) divison.

FIG. 31. Mitotic figure from the nucellus.

FIGS. 32–44. *Crucianella macrostachya.*

FIGS. 32–36. Pollen tetrad divisions.

FIG. 32. Prophase, first division.

FIG. 33. Metaphase, first division; ten chromosomes.

FIG. 34. Very early anaphase, first division.

FIG. 35. Metaphase, second division; one spindle in lateral and one in polar view; ten chromosomes.

FIG. 36. Chromosome pair, metaphase, second division.

FIGS. 37–42. Embryo-sac tetrad division.

FIGS. 37, 38. Prophase, first division.

FIGS. 39, 40. Early anaphase, first division.

FIG. 41. Separating chromosomes, anaphase, first division.

FIG. 42. Prophase, second division. Perinuclear radiations.

FIG. 43. First embryo-sac division.

FIG. 44. Separating chromosomes of the first embryo-sac division.

PLATE 12

FIGS. 1–12. *Diodia Virginiana*

FIG. 1. Basal partition with nucelli.

FIG. 2. Ovule with one-celled embryo-sac. *a*, *a'*, branches of vascular bundle.

FIG. 3. Part of young ovule, the integument commencing, showing archesporium.

FIG. 4. One-celled embryo-sac in migration. The remaining megaspores seen above following the embryo-sac.

FIG. 5. A similar condition in another ovule.

FIG. 6. Embryo-sac with nine antipodals.

FIG. 7. The four antipodal cells of an embryo-sac.

FIG. 8. Ovule with definitive embryo-sac, showing the relation of parts. *a*, *a'*, branches of vascular tissue. The isolated cells have appeared which later form a continuous plate as seen in *fig.* 9, *sp*.

FIG. 9. Older ovule.

FIGS. 10, 11, 12. The antipodal end of three embryo-sacs showing the number and arrangement of antipodal cells in each.

FIGS. 13–17. *Diodia teres*

FIG. 13. Basal partition and young nucelli.

FIG. 14. Somewhat older condition showing the strophiole (*st*) beginning to develop.

FIG. 15. Archesporium. One large functional megaspore mother-cell flanked by a smaller one.

FIG. 16. Young ovule with archesporial cell in its second division; strophiole well marked.

FIG. 17. Second division of the megaspore mother-cell.

PLATE 13

FIGS. 1–10. *Diodia teres*

FIG. 1. Young ovule, with one-celled embryo-sac. The strophiole is seen to close the micropyle.

FIG. 2. Archesporium showing the large, functional megaspore, and the three sister cells commencing to separate. The arrow indicates position of micropyle.

FIG. 3. Embryo-sac cell elongating; at the base are seen two nutritive cells.

FIG. 4. Two-celled embryo-sac.

FIG. 5. Embryo-sac.

FIG. 6. Embryo-sac after fertilization containing a one-celled embryo. The antipodals are still normal.

FIG. 7. The ovule in longitudinal section containing the embryo-sac shown in detail in Fig. 6.

FIG. 8. Still older condition with more advanced endosperm and embryo.

FIG. 9. Embryo of *fig.* 8 shown in detail.

FIG. 10. More advanced embryo, showing the suspensor after stretching.

FIGS. 11–18. *Richardsonia pilosa*

FIG. 11. Nucellus.

FIG. 12. Ovule with embryo-sac cell. The strophiole is seen.

FIG. 13. Embryo-sac cell.

FIG. 14. Embryo-sac showing small antipodals.

FIG. 15. An antipodal cell as it appears before the cell wall is secreted.

FIG. 16. Ovule with endosperm and embryo.

FIG. 17. Embryo of Fig. 16 in detail.

FIG. 18. Older embryo and the special cells of the endosperm.

PLATE 14. *Houstonia*

Lettering: *s*, stylar primordia; *p*, placental primordia; *r*, roof element of ovarial partition; *b*, basal element of ovarial partition; *ff*, plane of cell division adding to the funicle; *a*, antipodal cells.

FIG. 1. *H. coerulea.* Longitudinal section through a young flower.

FIG. 2. *H. longifolia.* Longitudinal section through an older flower.

FIG. 3. *H. longifolia.* A similar section after the fusion of the basal and roof partitions.

FIG. 4. A nucellus with a single functional megaspore mother-cell.

FIG. 5. Archesporium, showing two smaller megaspore mother-cells which do not divide. The arrow indicates the direction of the egg pole.

FIG. 6. Two megaspores formed, and the second daughter-cell in division.

FIG. 7. Embryo-sac with two cells.

FIG. 8. Ovule in which the embryo-sac contains four nuclei in telophase

FIG. 9. *H. coerulea.* Definitive embryo-sac. At the antipodal pole there are two megaspore mother-cells still persistent.

FIG. 10. *H. coerulea.* Ovule with three-celled embryo, and endosperm.

FIG. 11. One-celled embryo.

FIG. 12. Five-celled embryo.

PLATE 15

FIG. 1. Conductive epidermis (*Diodia Virginiana*) in young condition in the region of fusion between the roof and basal elements of the ovarial partition.

FIG. 2. A portion of the stylar conductive tissue penetrated by pollen tubes. Portions of three such tubes are shown.

FIG. 3. A portion of the stylar tissue showing a pollen tube taking a brief course making a large angle with the longitudinal axes of the cell (*Richardsonia pilosa*).

FIG. 4. Pollen tubes as seen in the base of the stylar tissue, turning to pass into the ovular conductive tissue (*R. pilosa*).

FIG. 5. Mouth of micropyle and adjacent conductive tissue, with a pollen tube (*R. pilosa*).

FIGS. 6, 7. Ovular conductive tissue of the kind seen in *fig. 5*, cut transversely to the longitudinal axes of the cells. Parts of pollen tubes are seen passing between the cells (*R. pilosa*).

FIG. 8. Conducting epidermis of *Diodia Virginiana.*

FIG. 9. A small portion of the surface of the conductive epidermis of *Diodia Virginiana* showing the pollen tube on the surface.

FIGS. 10, 11. Parts of pollen tube showing cellulose plugs (*Diodia Virginiana*).

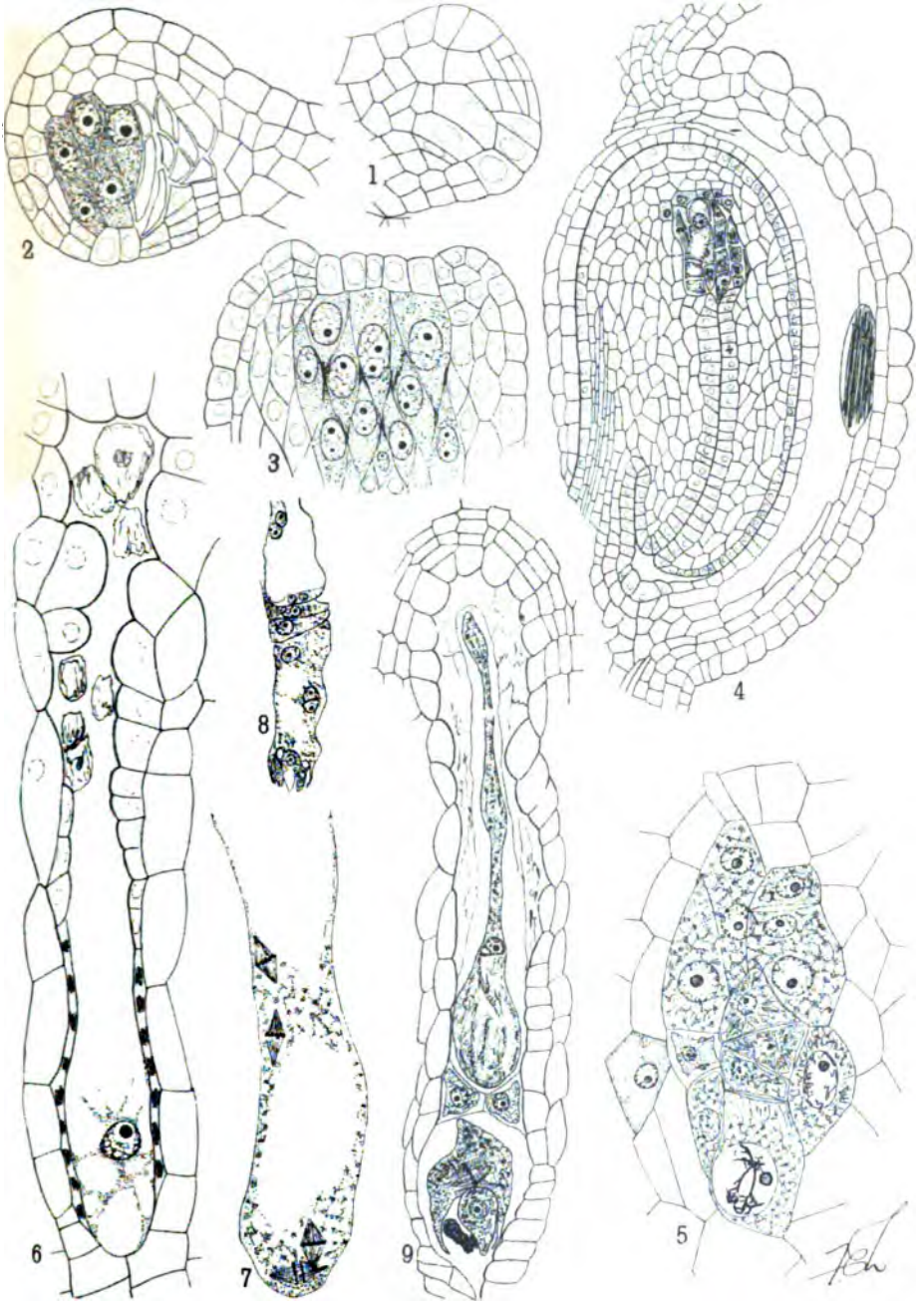
TABLE OF CONTENTS

PART 1

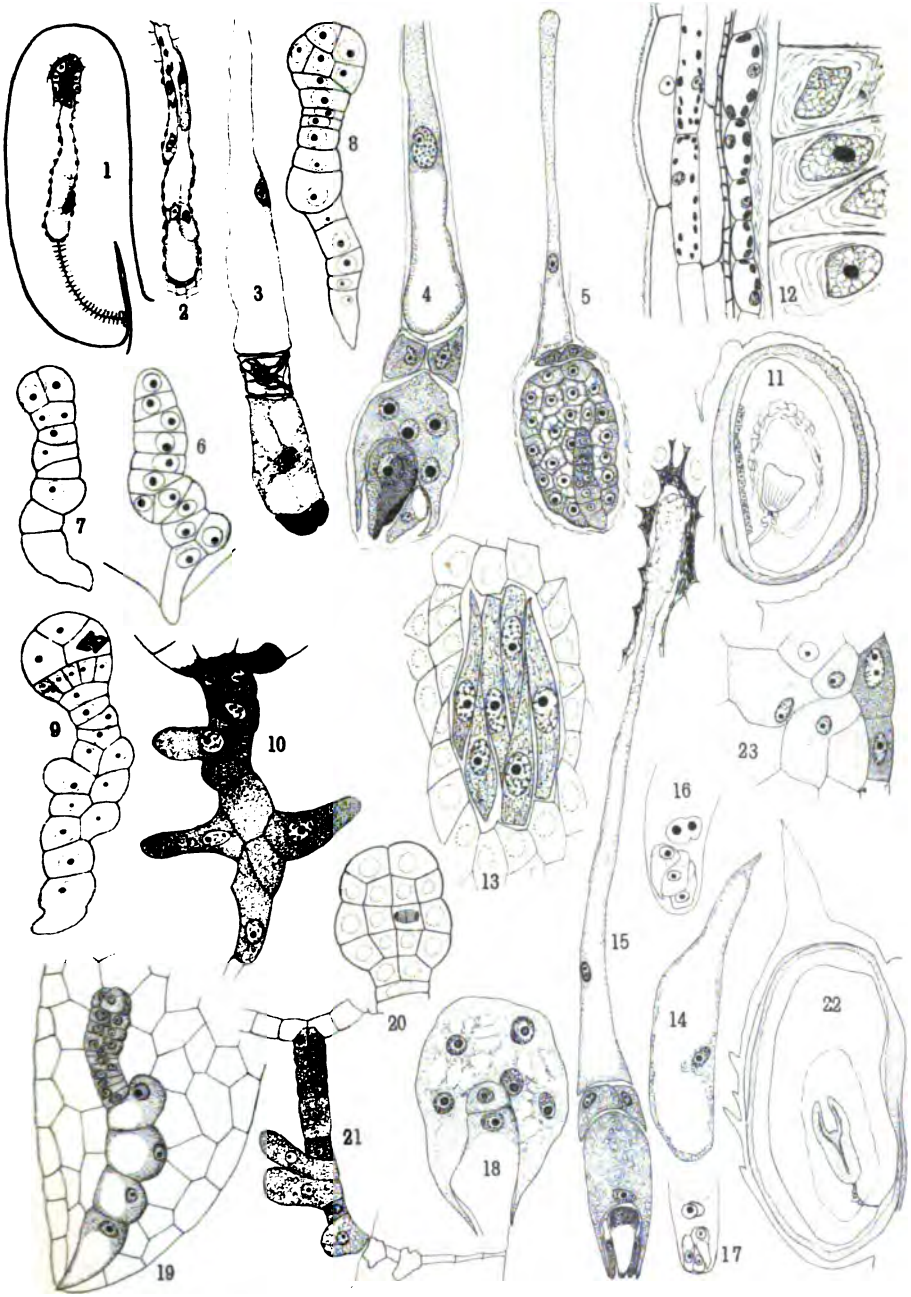
Introduction 1
Descriptive: *Vaillantia hispida* 8
Explanation of plates 23

PART 2

Further description of genera.
Callipeltis cucullaria 27
Sherardia arvensis 32
Galium 34
Asperula 36
Rubia tinctoria 43
Crucianella 44
Diodia Virginiana 48
Diodia teres 52
Richardsonia pilosa 54
Houstonia 56
Summary and conclusions 59
The tetrad and embryo-sac mitoses 66
Summary and conclusions 82
The behavior of the pollen tube
Diodia teres and *Richardsonia pilosa* 88
Diodia Virginiana 97
Results and conclusions 100
Bibliography 103
Explanation of plates 105



CALLIPELTIS CUCULLATA.



1-12. CALLIPELTIS CUCULLARIA.

13- 23. SHERARDIA ARVENSIS.

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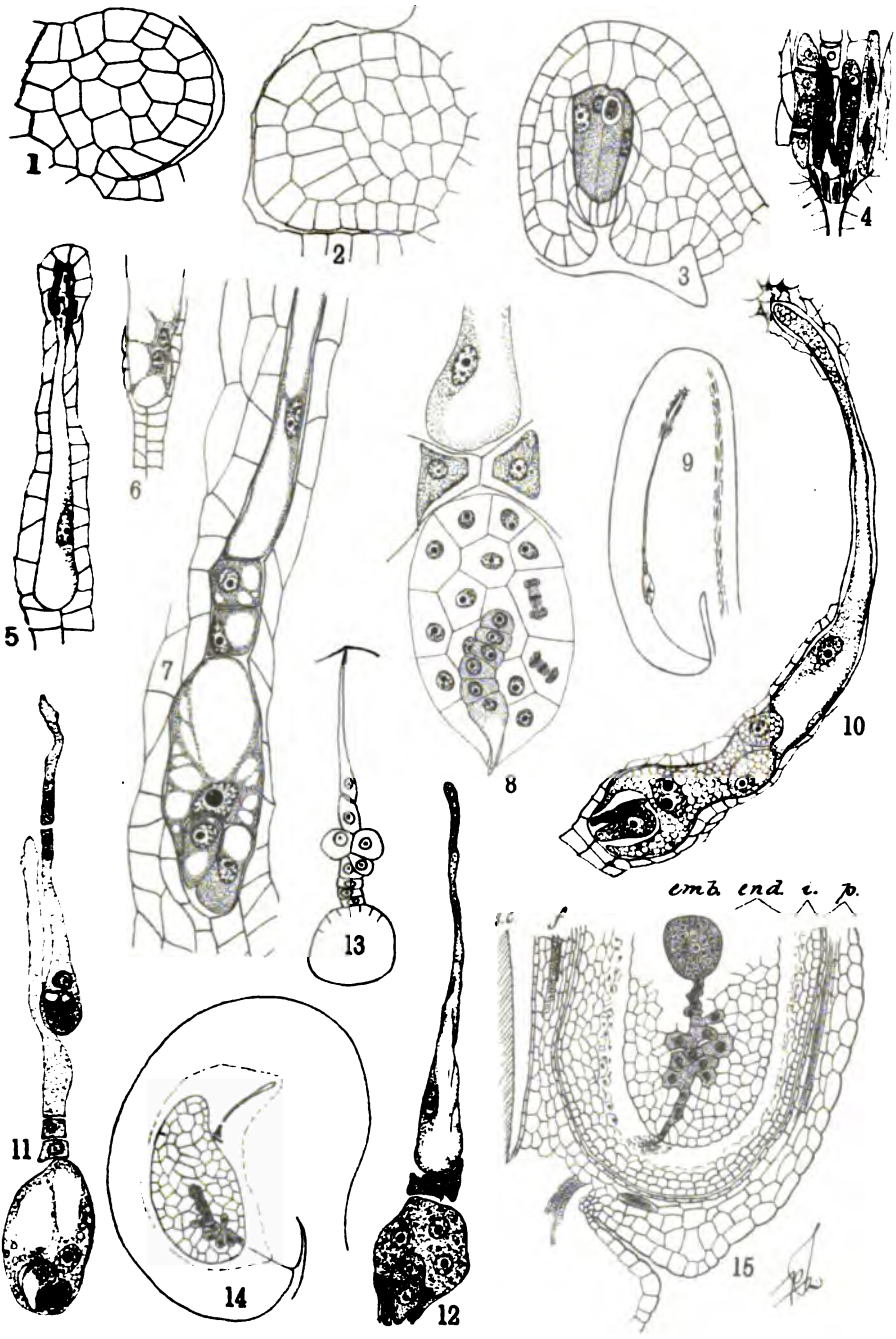

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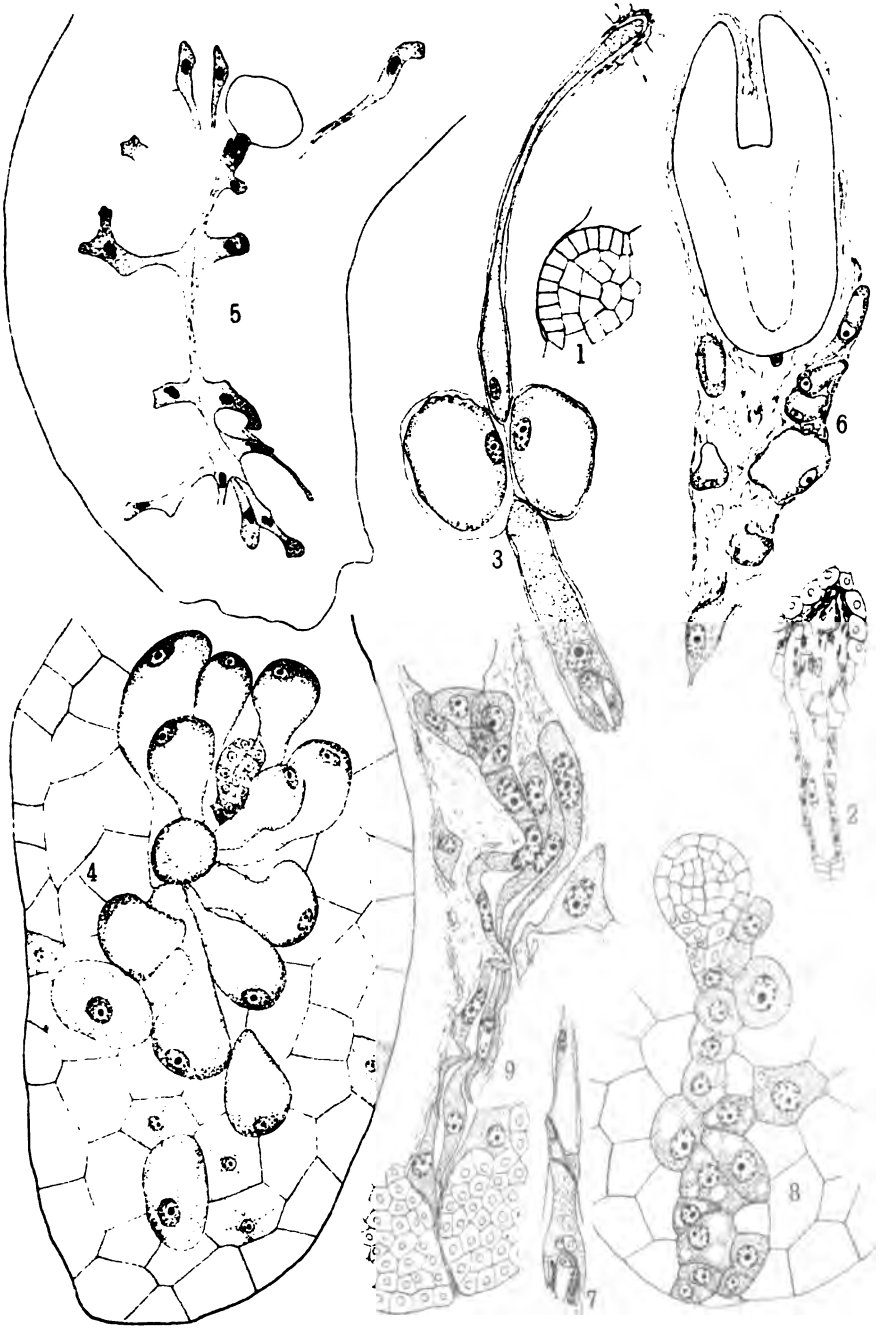
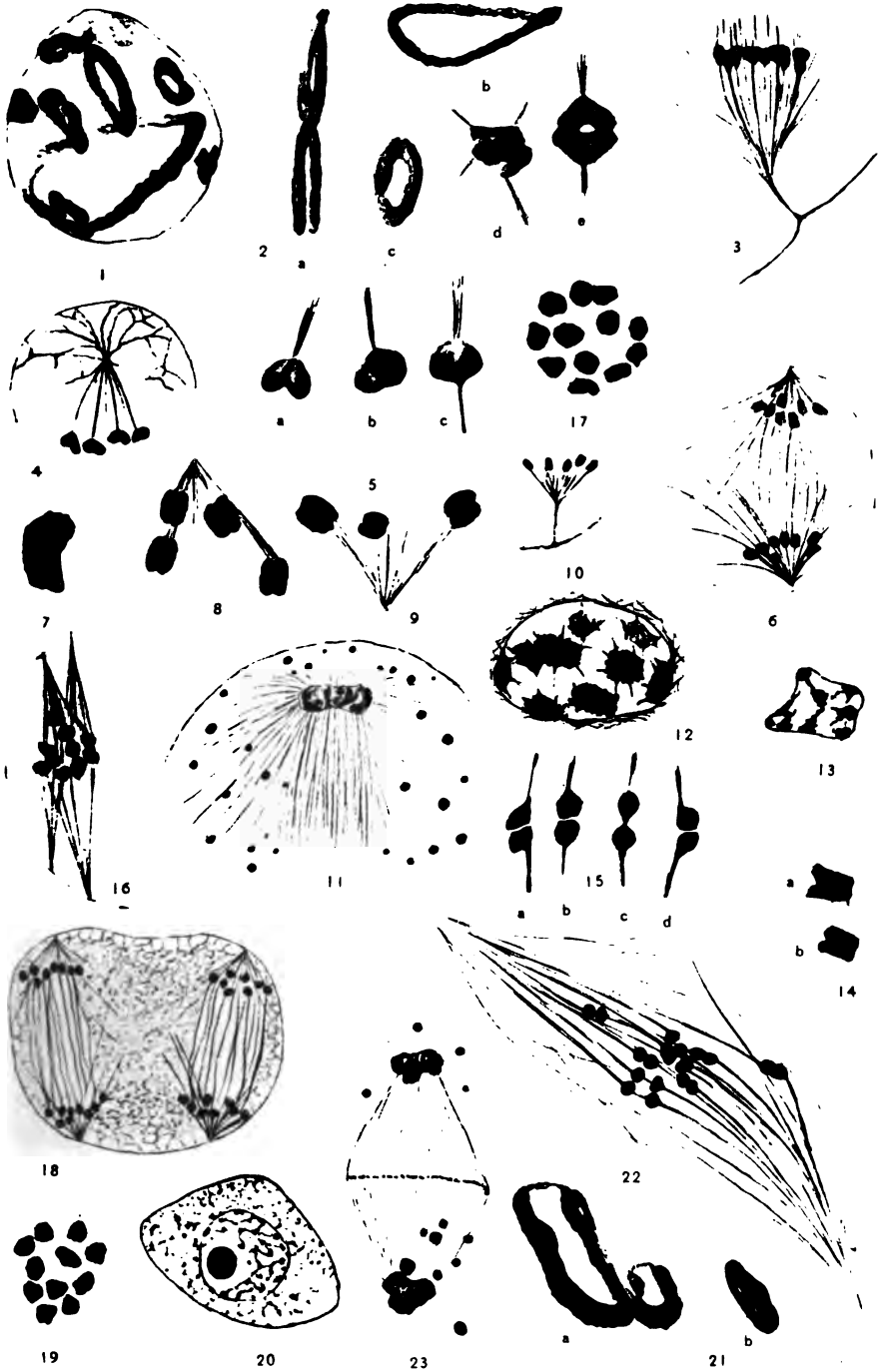
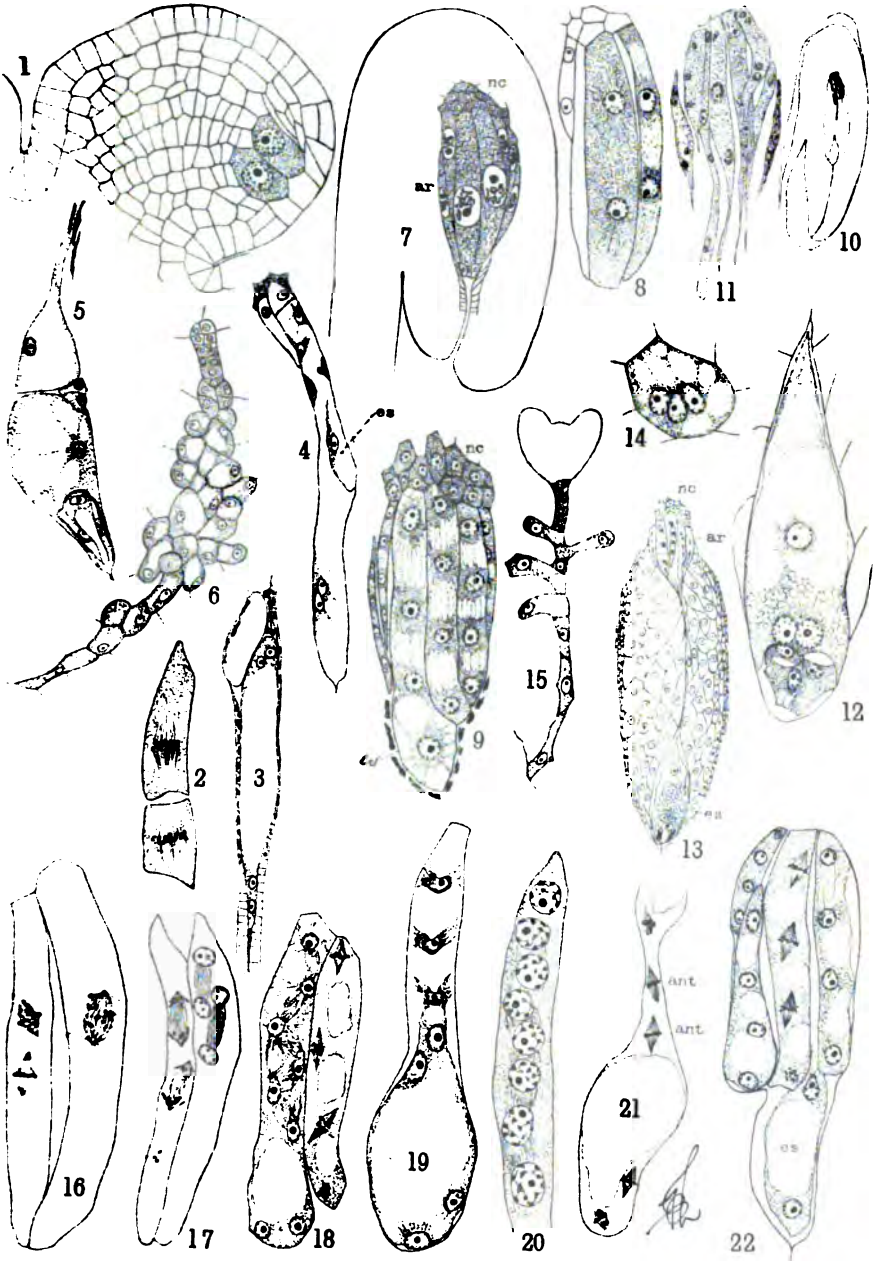


ASPERULA



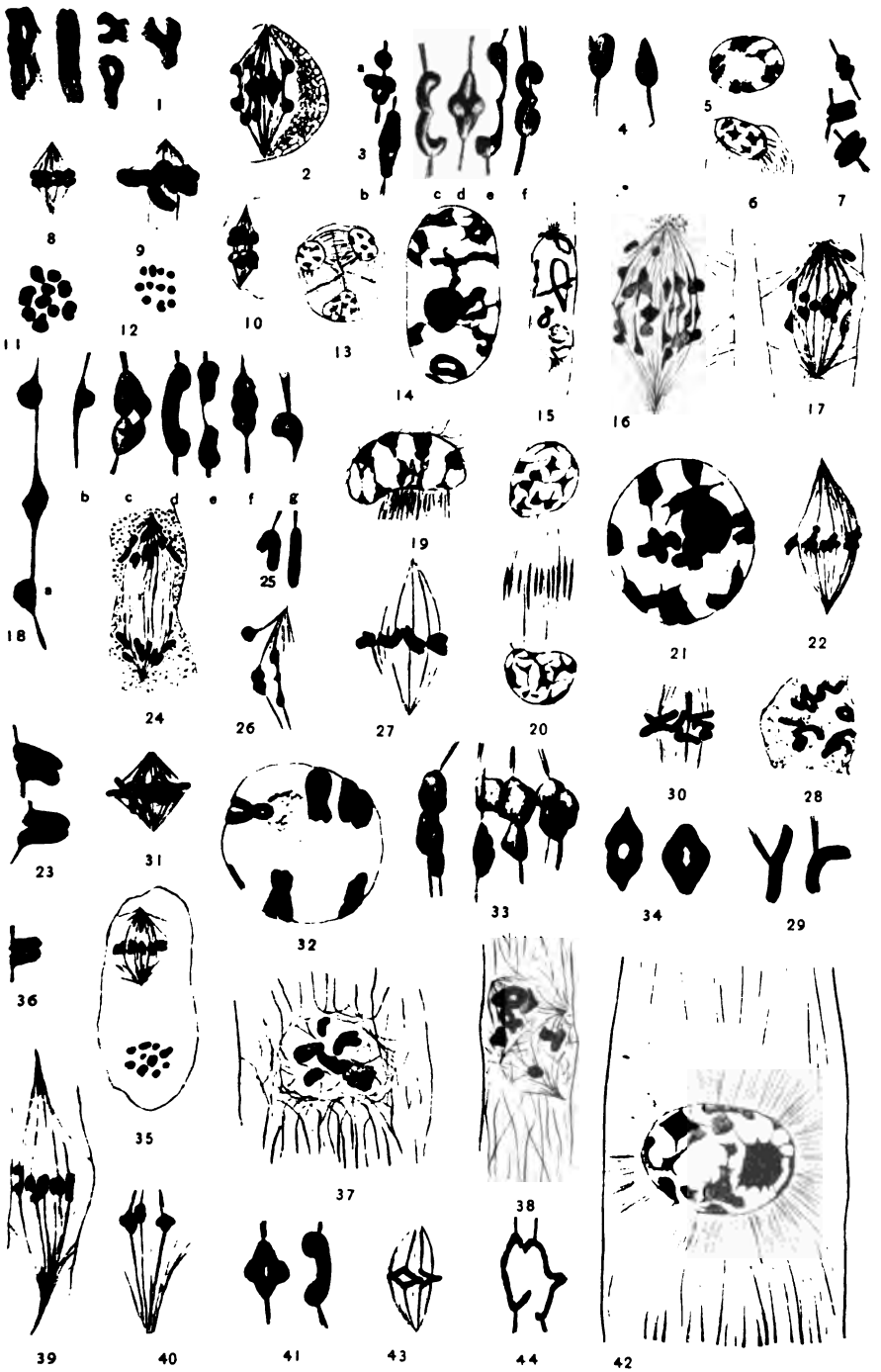
F. E. L. del.

ASPERULA MONTANA



1-6-RUBIA TINCTORIA

7-22-CRUCIANELLA



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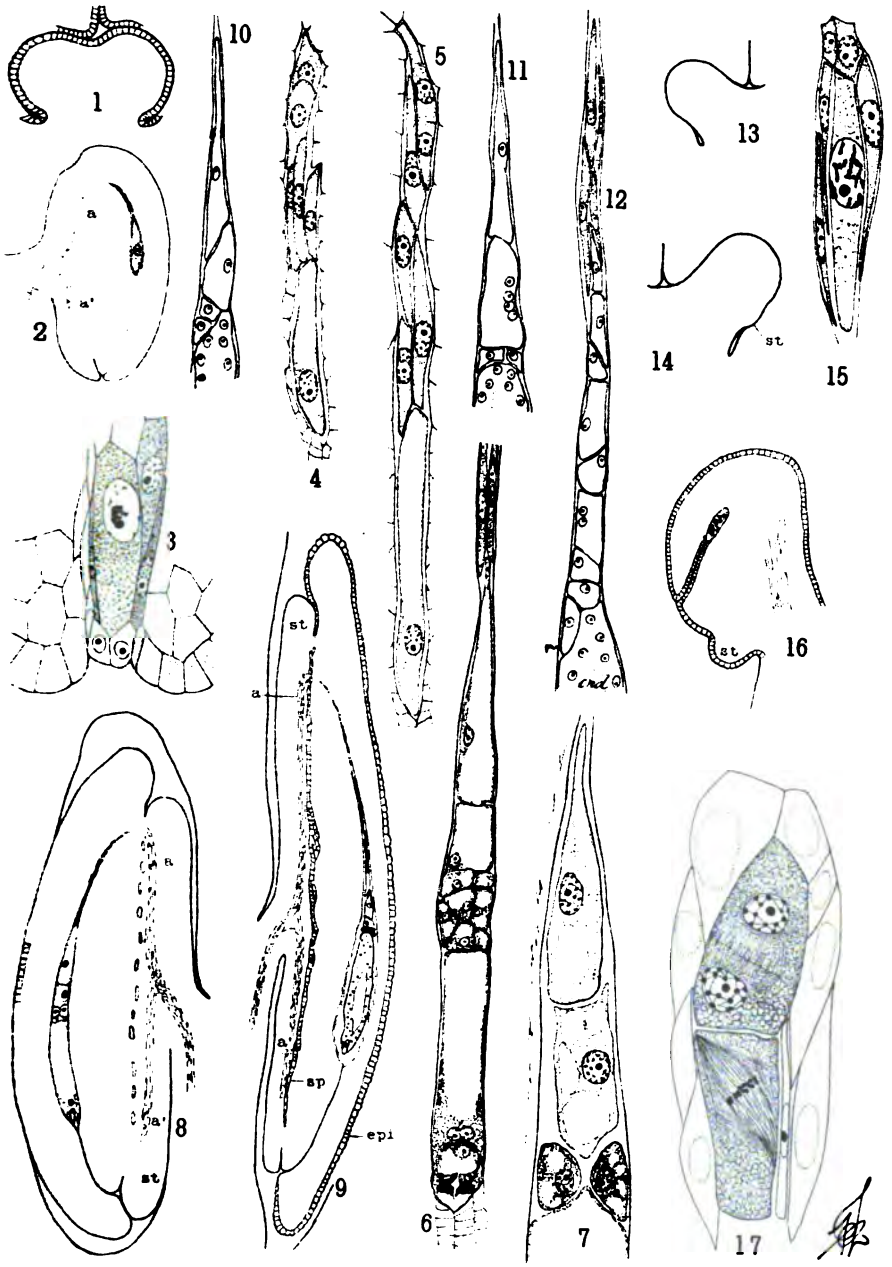
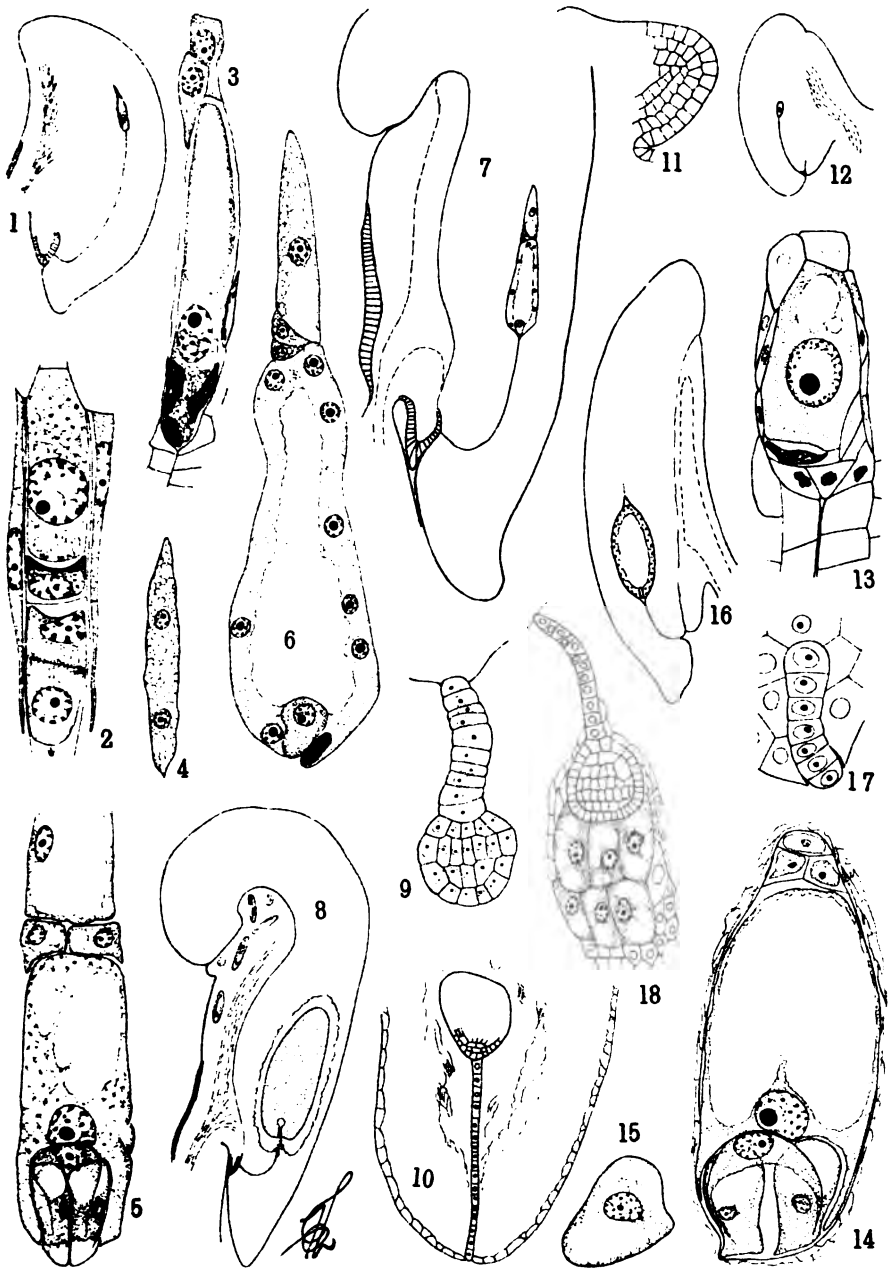
1-31-CRUCIANELLA GILANICA

32-44-CRUCIANELLA MACROSTACHYA



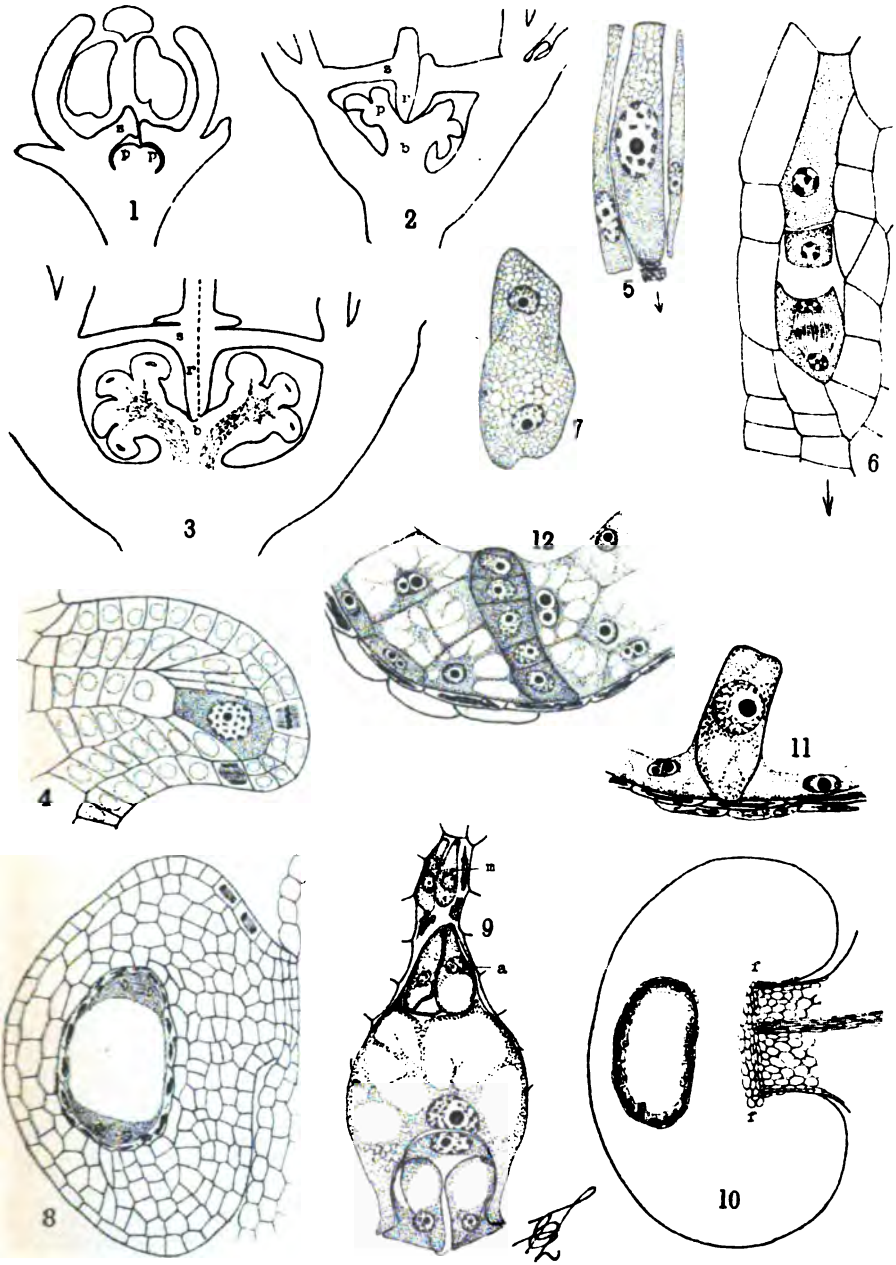
1-12-DIODIA VIRGINIANA

13-17-DIODIA TERES

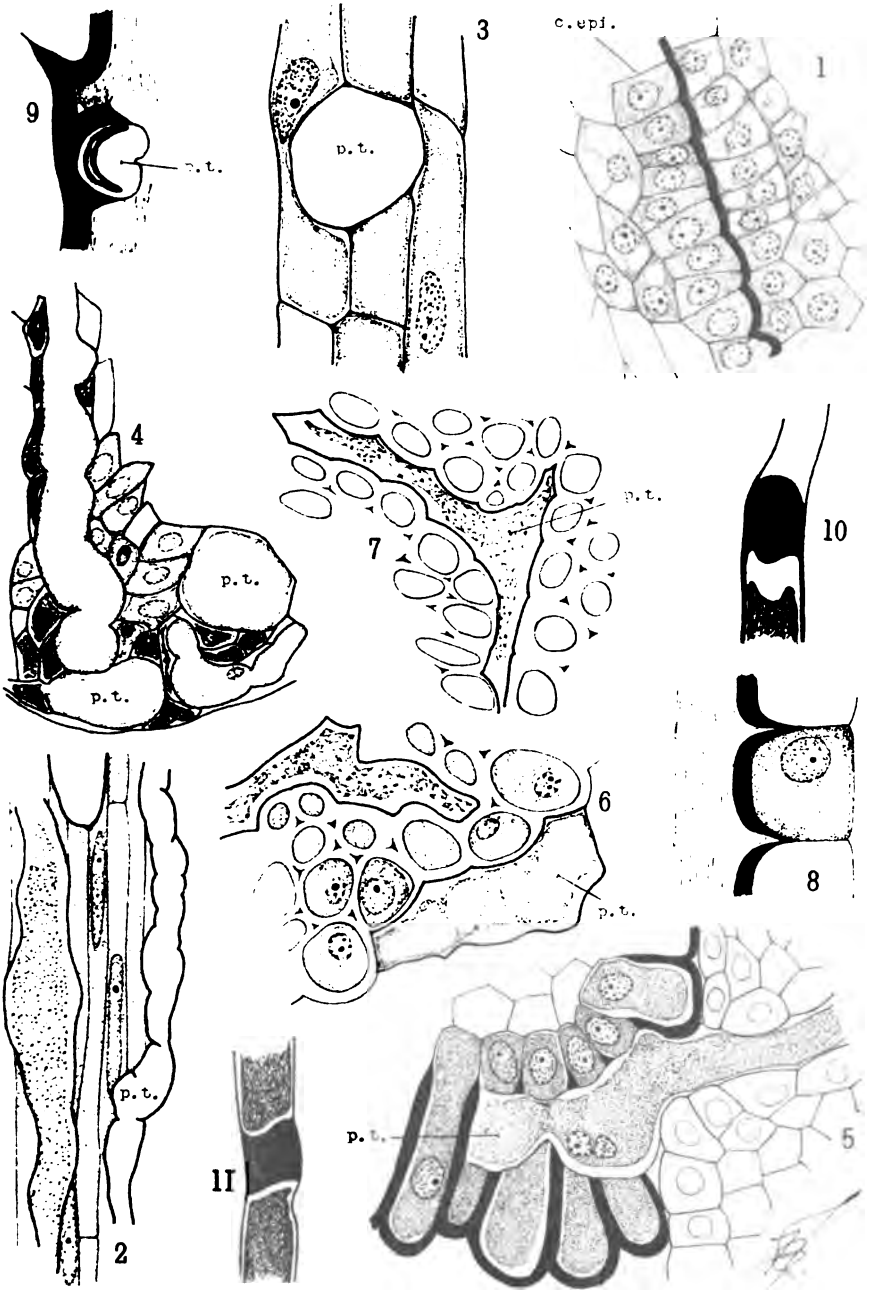


1-10-DIODIA TERES

11-18-RICHARDSONIA PILOSA



HOUSTONIA



BEHAVIOR OF POLLEN TUBE

The Lejeuneae of the United States and Canada

By Alexander W. Evans

(Plates 16–22)

The subtribe Lejeuneae, as defined by Schiffner, is made up of the large and comprehensive genus *Lejeunea* as understood by Spruce. The latter author divided this genus into thirty-seven natural divisions, which he looked upon as subgenera, while Schiffner raised nearly all of these subgenera to generic rank. Each of these authors has his own adherents. Writers on the hepaticae of Europe, where the Lejeuneae are poorly represented, tend to follow Spruce, recognizing but a single genus, while writers on the hepaticae of tropical regions, where the Lejeuneae attain a most luxuriant and varied development, tend to follow Schiffner. It is probable that an intermediate course would be more nearly correct, that some of Schiffner's genera are worthy of generic rank, but that others ought to be united. Until, however, the many species are more clearly defined and more accurately understood than they are at present, it seems most practicable, and perhaps wisest, to recognize Schiffner's genera as such, at least in a tentative way—a course which is adopted in the present paper.

For descriptions of the various genera, the reader is referred to the writings of Spruce * and of Schiffner.† Reference may also be made to a recent paper by the writer,‡ where the division of the group into genera is more fully discussed.

Historical

The earliest work devoted to North American hepaticae is that of Schweinitz, published in 1821. In this paper the genus *Jungermannia* is still used in its old sense and includes the Junger-

* Hep. Amaz. et And. 63–308. 1884.

† Engler & Prantl, Nat. Pflanzenfam. 1³: 117–131. 1893.

‡ The Hawaiian Hepaticae of the Tribe Jubuloideae. Trans. Conn. Acad. 10: 387–462. 1900.

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manniaceae and the Metzgeriaceae of recent American authors. Among the species referred to this genus are three which would now be included in the Lejeuneae. These are *J. serpyllifolia*, *J. transversalis* and *J. clypeata*. The first of these is a species which we share with Europe. It is the type-species of the genus *Lejeunea*, as originally described, and is now known as *Lejeunea serpyllifolia* Lib. or preferably as *L. cavifolia* (Ehrh.) Lindb. Apparently Schweinitz did not really know this species from America, the specimens so named in his herbarium being partly *Radula tenax* Lindb. and partly *Frullania Virginica* Gottsche. The second species is not the true West Indian *J. transversalis* Swartz, as Schweinitz supposed, but is the same as his *J. clypeata*, which he correctly distinguished as new. This third species is now referred to the genus *Archilejeunea*. Apparently in ignorance of Schweinitz's paper, Lehmann, in 1838, described the same species as new under the name *Lejeunea Dorotheae*.

In 1841 and in 1845 two important exsiccatae of North American bryophytes appeared in which several Lejeuneae were included. In the first of these, Drummond's Mosses of the Southern States, the specimens were determined by Wilson and Hooker and, in the case of new species, were accompanied by printed descriptions. The Lejeuneae of this collection are labeled *Jungermannia serpyllifolia*, *J. auriculata* and *J. parvula*, the last two being described as new. The first of these is not correctly determined and is in fact a mixture of two distinct species, *Euosmolejeunea duriuscula* (Nees) and *Lejeunea Americana* (Lindb.), proposed as a species in the present paper. *J. auriculata* is the type of *Mastigolejeunea auriculata* Schiffn., a species now known to have a wide distribution in tropical America. *J. parvula*, however, is apparently the same as the European *Cololejeunea minutissima* (Sm.) Schiffn., which has subsequently been collected many times in our Southern States. In the second exsiccata, Sullivant's Musci Alleghanienses, we find six Lejeuneae—*Phragmicoma clypeata*, *Lejeunea serpyllifolia*, *L. serpyllifolia* var., *L. cucullata*, *L. calcarea* and *L. minutissima*. The first and last of these are correctly determined. Of the remainder, *L. serpyllifolia* is really *L. Americana*; *L. serpyllifolia* var. is *Euosmolejeunea duriuscula*; *L. cucullata*, although compared by Sullivant with a specimen communicated by Montagne,

is not the same as what we now call *Microlejeunea cucullata* (R. Bl. & N.) Jack & Steph., of Java, but is apparently to be referred to *Microlejeunea lucens* (Tayl.), a species at that time undescribed; while *L. calcarea* is not precisely the same as the European *Cololejeunea calcarea* (Lib.) Schiffn. but agrees better with the North American representative of this species, *C. Biddlecomiae* (Aust.), which was not published until 1890.

The next notes we find on our Lejeuneae are by European writers. From 1844 to 1847 Gottsche, Lindenberg and Nees von Esenbeck issued their classical Synopsis Hepaticarum in five parts. The Lejeuneae are treated in the second and third parts, which appeared in 1845, and in the fifth or supplementary part, which was published two years later. In the second and third parts the following five Lejeuneae are recorded from North America: *Phragmicoma versicolor*, *Lejeunea transversalis*, *L. catenulata*, *L. Dorotheae* and *L. serpyllifolia*. The first of these species is a composite; so far as American material is concerned, it is the same as *Jungermannia auriculata* Wils. & Hook., which is unjustly reduced to it as a synonym. *Lejeunea transversalis* is admitted solely on the authority of Schweinitz. *L. catenulata*, under which *Jungermannia transversalis* Schwein. strangely appears as a synonym, is *Neurolejeunea catenulata* (Nees) Schiffn. It is a species of tropical America, but there is no adequate evidence that it occurs within the United States. The last two species require no comment. In 1846 Taylor described a large number of new hepaticae from various parts of the world and among them six Lejeuneae, presumably from North America. Many years later it was proved that four of these species, viz.: *Phragmicoma testudinea*, *P. cyclostipa*, *Lejeunea polyphylla* and *L. longiflora*,* did not come from Ohio at all, as Taylor supposed, but were really collected near Pará in Brazil. A fifth species, *L. calyculata*, is a synonym of *Archilejeunea clypeata*. It is probable that the sixth species, *L. lucens*, was also originally collected at Pará. This plant, however, has a wide

* All four of these species are reduced to synonymy by Stephani (Hedwigia, 29: 1890). *Phragmicoma testudinea* is *Pycnolejeunea macroloba* (Mont.) Schiffn., *Phragmicoma cyclostipa* is a mixture of *Archilejeunea Auberiana* (Mont.) Steph., and *Lopholejeunea Sagraeana* (Mont.) Schiffn.; *Lejeunea polyphylla* is *Acrolejeunea torulosa* (Lehm. & Lindenb.) Schiffn.; while *L. longiflora* is a form of the widely distributed *Euosmolejeunea trifaria* (Ness) Schiffn., of tropical regions.

range, extending into the United States and is apparently the same as Sullivant's *L. cucullata*. In the supplementary part of the Synopsis Hepaticarum these six species of Taylor are quoted with little comment, and *L. minutissima*, *L. calcarea* and *L. cucullata* are recorded from North America on the authority of Sullivant.

The first and second editions of Gray's Manual contain descriptions of the hepaticae by Sullivant. In the first edition, published in 1848, only four Lejeuneae are included. These are *L. serpyllifolia*, *L. clypeata*, *L. calcarea* and *L. cucullata*. In the second edition, published in 1856, species from the Southern States are added, and we find eleven Lejeuneae. The list includes the four species quoted above, Taylor's six new species, as well as *L. minutissima* and *L. auriculata*. *L. lucens* Tayl., however, is quoted merely as a synonym of *L. cucullata*.

In Austin's papers on hepaticae, published from 1869 to 1879, we find seven species of Lejeuneae described as new and three species recorded for the first time from the United States. Two of the new species, *L. Sullivantiae* ('72) and *L. Mohrii* ('75) are now reduced to synonymy ; the first being referable to *Euosmolejeunea duriuscula* and the second to *E. opaca* (Gottsche) Steph. A third species, *L. biseriata* ('69) proved to be a moss, as Austin himself afterwards decided. Three other species, *L. Ravenelii*, *L. Caroliniana* and *L. laete-fusca*, all published in 1876, are so incompletely described that we know little about them. Even the type specimens, where accessible, do not aid us ; they are very fragmentary and are either sterile or in poor condition. Under the circumstances it seems advisable to allow these three names to disappear from our literature. Austin's seventh species, the only one here retained, is *L. Jooriana* ('75), which belongs to the genus *Cololejeunea*. Of the three species which Austin first accredited to the United States, *Phragmicoma xanthocarpa* does not agree with authentic specimens of this widely distributed tropical species but should be referred to *Archilejeunea Sellowiana* Steph.; the specimens referred to the European *Lejeunea ovata*, now *Harpalejeunea ovata* (Hook.) Schiffn., are probably correctly named ; while those referred to *L. laete-virens* Mont., a West Indian species, are in too poor a condition to be definitely determined.

In 1875 the Finnish botanist, Lindberg, in a lengthy paper on

Irish hepaticae, includes interesting notes on some of the Lejeuneae in American exsiccatae. The most important of these are the following: *Lejeunea ulicina*, of Europe, is accredited to North America; *L. parvula* (the *Jungermannia parvula* of Drummond's collection) is recognized as a species, and Sullivant's *L. minutissima* is reduced to it as a synonym; the American specimens of *L. serpyllifolia* are all referred to the new var. *Americana* Lindb.; *L. Sullivantiae* Aust. is given the new name *L. Austini* Lindb., on account of the previously described *L. Sullivantii* Gottsche. The evidence that *Microlejeunea ulicina* (Tayl.) occurs in North America does not seem to be conclusive. *Lejeunea parvula* and *L. Sullivantiae* have already been commented upon. Lindberg's var. *Americana* is a composite, and, while it includes the *L. Americana* of the present paper, it includes also typical *L. cavifolia*.

In 1884 Spruce, in his important work on South American hepaticae, accredits the rare European *L. diversiloba* Spruce to North America. He apparently refers to this species the specimens which Sullivant called *L. cucullata*, although this is not definitely stated. Three years afterwards Spruce referred Sullivant's specimens somewhat doubtfully to *L. lucens* Tayl.

The numerous papers on hepaticae by Underwood contain frequent references to the Lejeuneae. In his preliminary list of North American species, published in 1882, fourteen species of Lejeuneae are noted. In his Descriptive Catalogue of 1884, descriptions are given of these fourteen species and of four others omitted from the earlier list. All of these species had been previously recorded. In the sixth edition of Gray's Manual, published in 1890, Underwood described the hepaticae, and it is interesting to note that the four Lejeuneae which he there recognizes are the same ones which Sullivant described in the first edition of the Manual, forty-two years before. In the same year Underwood published a description of *Lejeunea Macounii* Spruce, and Pearson, a plate of *L. Biddlecomiae* Aust., accompanied by descriptive notes. Both of these species belong to the genus *Cololejeunea*. Two years later Underwood recorded another *Cololejeunea*, the European *L. Rossettiana* Massal., but there seems to be no very adequate evidence that this species has been collected in America.

The last published list of North American Lejeuneae is that of

Stephani, which appeared in 1892. Twenty species are recognized; of these, *Lejeunea* (*Eu-Lejeunea*) *Underwoodii* and *L.* (*Micro-Lejeunea*) *Cardoti* are described as new, while *L.* (*Euosmo-Lejeunea*) *trifaria* Nees and *L.* (*Colo-Lejeunea*) *Wrightii* Gottsche are recorded for the first time from the United States. The first of the new species, judging from authentic specimens, is identical with *Lejeunea Sullivantiae* Aust. and is therefore a form of *Euosmolejeunea duriuscula;* the second, however, seems to be distinct. The specimens referred to *Euosmolejeunea trifaria* are dioicous and agree with *E. opaca*, while those referred to the undescribed *Lejeunea Wrightii*, from Cuba, are apparently an abnormally developed form of *Cololejeunea minutissima*. In 1895 Stephani accredited *Lejeunea flava* Swartz to Florida. The occurrence of this widely distributed species is certainly to be expected within our limits, but a specimen from Florida collected by Rau and determined as *L. flava* by Stephani himself seems to be referable to Spruce's var. *albida* of this species, a plant which the writer is unable to distinguish from *L. Americana*.

In the Hepaticae Americanae of Underwood and Cook, the first decade of which appeared in 1887, and which is still unfinished, a number of Lejeuneae have been distributed. Those from the United States or Canada will be noted in connection with the description of species.

It will be seen from the preceding account that the opinions of writers with regard to several of our species have been both varied and uncertain. This fact becomes even more evident when we consult the Lejeuneae in herbaria or in published exsiccatae. We are almost certain to find many false determinations among them. In some cases a single species will appear under several different names; in other cases several distinct species will appear under the same name. This confusion is partly because the Lejeuneae often grow mixed together, partly because certain of the species are extremely variable, and partly because the published descriptions, especially those of the older writers, are often so general and so incomplete as to be quite valueless. It becomes often necessary therefore to examine type-specimens, in order to learn upon what particular form a given species was originally founded. It becomes equally necessary, in the case of a variable species of wide

range, to examine a large series of specimens from as many different localities as possible. It is only by this latter method that one can acquire a sufficient knowledge to distinguish between specific characters and those peculiarities which are simply due to variability. It should also be remembered in this connection that plants which grow under abnormal conditions tend to develop abnormally or imperfectly, and this is most strikingly true of the Lejeuneae. It may even happen that a specimen bearing perianths and capsules may utterly fail to show the foliar characters of the species, on account of the crowding together of the fruiting branches. Such abnormal specimens, although interesting from a morphological point of view, cannot always be determined with certainty, and yet it is unfortunately true that many species of Lejeuneae have been founded on just such forms. It is sometimes a question as to what should be done with species whose type-specimens are of this character, but probably in doubtful cases the best course is to discard them altogether.

DISTRIBUTION OF SPECIES

As a result of his own studies the writer is able to distinguish twenty-three species for the United States and Canada. Three of these are proposed as new, one is raised from varietal rank and six are recorded for the first time. The remaining species have all been previously noted. Four of our species occur in Europe, thirteen are more or less widely distributed in tropical America and six appear to be endemic. It should be noted, however, that two of these six species have near relatives in Europe and that the remaining four are closely allied to species of tropical America. It is very probable also that the ranges of several of these apparently endemic species will be extended into tropical regions by future explorations. Three of our species, *Lejeunea cavifolia*, *L. patens* and *Cololejeunea Macounii* are distinctly northern in their distribution. *Archilejeunea clypeata*, *A. Sellowiana* and *Cololejeunea Biddlecomiae* all have wide ranges extending from eastern Canada or New England to or beyond the Gulf States. *Harpalejeunea ovata* has been found from Virginia to northern Georgia, while *Microlejeunea Ruthii* has been collected only in Tennessee. Our other species are characteristically southern, although *Lejeunea*

Americana and *Cololejeunea Jooriana* have been found as far north as North Carolina, and *Microlejeunea lucens* apparently occurs in Virginia. Six of these southern species have not been collected outside of Florida. With the exception of *Cololejeunea Macounii*, of British Columbia, no species are known from the Pacific Coast region; no species moreover have been reported from the Rocky Mountains nor from the Great Plains east of the Rocky Mountains, their absence or scarcity apparently being due to the dry atmospheric conditions. With regard to the number of species in individual States, Florida leads with fifteen, Louisiana ranks second with nine and Alabama third with eight. Few of the remaining States have more than three species apiece, and even east of the Mississippi River there are several States which have had no Lejeuneae whatever reported from them.

The brief notes which have just been given are mainly of temporary value. The Lejeuneae have been so largely neglected by collectors that our knowledge of their geographical distribution is at best very incomplete. The rich harvest of species which Underwood gathered in Florida shows how little we had previously known about the Lejeuneae of that state and indicates that much is still to be learned. The collections of Langlois in Louisiana and of Mohr in Alabama point to similar conclusions. Even in the north, the recent discovery of *Lejeunea patens* in Newfoundland and in Cape Breton shows how fragmentary our knowledge really is. It should be noted also that specimens exist in herbaria, too incomplete for identification and yet undoubtedly distinct from any recorded species. Some of these are probably identical with described species from tropical America, others are probably undescribed; but for the present they must be left in doubt. It is clear, therefore, that much remains to be done to complete our knowledge of the Lejeuneae, and it is to be hoped that the present paper may incite collectors to pay more attention to these inconspicuous but beautiful plants.

The revision which follows is based largely on the collections of Lejeuneae in the Underwood herbarium, in the United States National Herbarium and in the herbaria at Yale University. The curators of other herbaria have also been most generous in allow-

ing the writer to examine type specimens in their charge, and other correspondents have kindly furnished material for study.

Analytical Key to the Species

1. Underleaves present, undivided. 2.
   Underleaves present, bifid. 6.
   Underleaves absent. 19.

2. Plants pale, perianth five-keeled. 3.
   Plants more or less tinged with brown or purple. 5.

3. Lobule bluntly pointed at the apex or apiculate. 1. *Archilejeunea clypeata.*
   Lobule with a long and slender apical tooth. 4.

4. Lobe widely spreading, slightly convex or plane, averaging 1.2 × 0.95 mm., postical margin usually forming a distinct angle with keel. 2. *Archilejeunea Sellowiana.*
   Lobe obliquely spreading, strongly convex, averaging 0.7 × 0.45 mm., postical margin usually forming a continuous line with keel. 3. *Archilejeunea conchifolia.*

5. Lobule entire on margin or with a single apical tooth, median leaf-cells averaging 21 × 12 μ, ♀ inflorescence usually innovating or only one side, perianth trigonous throughout. 4. *Mastigolejeunea auriculata.*
   Lobule crenulate on margin with about four teeth, median leaf-cells averaging 23 × 16 μ, ♀ inflorescence usually innovating on both sides, perianth six- to eight-plicate in upper part. 5. *Brachiolejeunea corticalis.*

6. Lobe acute, at least on well developed leaves, underleaves with rounded division, and broad, shallow sinus. 6. *Harpalejeunea ovata.*
   Lobe rounded or rarely obtuse, underleaves with obtuse to acute divisions and narrow sinus. 7.

7. Plants firm in texture, yellowish- or brownish-green, inflorescence dioicous. 8.
   Plants delicate in texture, whitish or pale green, varying to dark green. 10.

8. Underleaves small, distant, narrowed toward base. 7. *Euosmolejeunea duriuscula.*
   Underleaves large, contiguous to imbricated, rounded or cordate at base. 9.

9. Leaves loosely imbricated, the lobe broadly ovate, obliquely spreading. 8. *Euosmolejeunea opaca.*
   Leaves densely imbricated, the lobe orbicular, widely spreading. 9. *Cheilolejeunea polyantha.*

10. Branches sometimes flagelliform and leafless but with persistent underleaves, lobule inflated, perianth (so far as known) with a plane antical face. 11.
    Branches never flagelliform. 12.

11. Lobes without basal ocelli, median leaf-cells averaging 21 μ in diameter, inflorescence autoicous. 10. *Cheilolejeunea phyllobola.*
    Lobes with basal ocelli, median leaf-cells averaging 10 μ in diameter, inflorescence dioicous. 11. *Cheilolejeunea versifolia.*

12. Lobule filiform, not inflated, inflorescence autoicous, perianth plane or nearly so on antical face. 12. *Cheilolejeunea pililoba.*
    Lobule inflated, perianth with a distinct antical keel. 13.

13. Lobe widely spreading, inflorescence autoicous. 14.
    Lobe obliquely spreading to suberect, inflorescence dioicous. 16.

14. Lobes and underleaves distinctly crenulate on the margins, underleaves smaller than lobules. 13. *Lejeunea patens.*
Lobes and underleaves entire or nearly so. 15.

15. Plants pale to dark green, underleaves as large as lobules or larger, not rounded at base, perianth abruptly narrowed at base. 14. *Lejeunea cavifolia.*
Plants pale, underleaves larger than lobules, rounded at base, perianth gradually narrowed toward base. 15. *Lejeunea Americana.*

16. Median leaf-cells 18–20 μ in diameter. 17.
Median leaf-cells 12–13 μ in diameter. 18.

17. Underleaves longer than broad, deeply bifid, often unidentate on sides. 16. *Microlejeunea lucens.*
Underleaves as broad as long, bifid to middle, never unidentate on sides. 17. *Microlejeunea Rutkii.*

18. Lobule much smaller than lobe, often obsolete, lobe indistinctly ocellate at base, averaging 0.25 mm. in length. 18. *Microlejeunea Cardoti.*
Lobule nearly as large as lobe, lobe not ocellate at base, averaging 0.17 mm. in length. 19. *Microlejeunea bullata.*

19. Lobule three fourths the length of lobe or longer, lobe rounded at the apex and without hyaline cells, crenulate on the margin, stylus reduced to a single papilla, inflorescence autoicous. 20. *Cololejeunea minutissima.*
Lobule about half as long as lobe. 20.

20. Outer surface of lobe rough from projecting cells or wart-like thickenings or both, hyaline cells absent, inflorescence dioicous or autoicous. 21.
Outer surface of lobe almost smooth, the cells scarcely if at all convex, hyaline cells often present at the apex and along antical margin, stylus usually two cells long, inflorescence synoicous or paroicous. 23. *Cololejeunea Joriana.*

21. Lobe narrowed toward the apex, with strongly convex or conical cells, the projecting wall sometimes thickened, stylus usually two to ten cells long. 21. *Cololejeunea Biddlecomiae.*
Lobe broad at the apex, with slightly convex cells, each bearing in the middle a large globoid thickening, stylus usually two cells long. 22. *Cololejeunea Macounii.*

DESCRIPTION OF SPECIES

1. ARCHILEJEUNEA CLYPEATA (Schwein.) Schiffn.

PLATE 16, FIGS. 1–11

Jungermannia clypeata Schwein. Spec. Fl. Amer. Sept. Crypt. Hep. 12. 1821.

Jungermannia transversalis Schwein. *l. c.* (not Swartz).

Phragmicoma clypeata Nees, Naturgesch. Eur. Leberm. 3: 248. 1838.

Lejeunea Dorotheae Lehm. Pugillus, 7: 17. 1838. G. L. & N. Syn. Hep. 332. 1845.

Lejeunea Carolinensis Mont.; G. L. & N. *l. c.* (as synonym).

Lejeunea calyculata Tayl. Lond. Jour. Bot. **5**: 388. 1846. G. L. & N. Syn. Hep. 752. 1847.

Lejeunea clypeata Sull.; Gray, Manual, Ed. I., 685. 1848.

Symbiezidium calyculatum Trevis. Mem. r. 1st. Lomb. III. **4**: 403. 1877.

Lejeunea (*Archi-Lejeunea*) *clypeata* Spruce, Hep. Amaz. et And. 90. 1884.

Archilejeunea clypeata Schiffn.; Engler & Prantl, Nat. Pflanzenfam. I^3: 130. 1893.

Pale glaucous-green or whitish, growing in broad depressed mats: stems prostrate, 0.085 mm. in diameter, closely appressed to matrix, irregularly branched: rhizoids scanty, simple or branched: leaves imbricated, the lobe obliquely spreading, slightly falcate, broadly oblong to suborbicular, convex, averaging 0.6 mm. long and 0.45 mm. wide, slightly revolute at the rounded apex, margin crenulate from projecting cells, antical margin rounded at base and arching across or just beyond axis; lobule inflated, ovate-triangular, 0.2 mm. long, 0.12 mm. wide, keel straight or slightly curved, forming a very obtuse angle with postical margin of lobe and sometimes almost continuous with it, free margin slightly curved, involute to beyond apex, then obliquely truncate to end of keel, apex blunt or subacute, consisting of a single projecting cell or rarely of two cells; cells of lobe convex with rather thick projecting walls and thin vertical walls, trigones distinct though sometimes small, acuminate, indeterminate thickenings absent except sometimes near base of lobe, cells at edge of lobe 15 μ in diameter, in the middle and at the base 19 μ: underleaves distant, orbicular, 0.2 mm. long, rounded at the apex, abruptly narrowed and neither rounded nor cordate at base, very short decurrent and attached by a slightly curved line of insertion: inflorescence autoicous or dioicous: ♀ inflorescence usually borne on a leading branch, rarely on a short branch, innovating on one or rarely on both sides, the innovations usually simple and sterile; bracts complicate, unequally bifid, scarcely or not at all winged on keel, the lobe obovate, slightly falcate, rounded at the apex, 0.75 mm. long, 0.45 mm. wide, crenulate on the margins, lobule oblong, rounded at the apex, 0.4 mm. long, 0.12 mm. wide; bracteole ovate-oblong, 0.6 mm. long, 0.4 mm. wide, slightly narrowed toward base, truncate or rarely retuse at the broad apex; perianth obovoid, 0.85 mm. long, 0.6 mm. wide, cuneate toward base, truncate above and with a short broad beak, lateral keels sharp, antical keel short and low, postical keel long, broad and sharply two-

angled when young, the keels roughened from projecting cells or sometimes with narrow rudimentary wings: ♂ spikes occupying short branches, oblong; bracts closely imbricated in two to four pairs, strongly inflated, slightly and subequally bifid with rounded lobes and strongly arched keel; bracteoles similar to the underleaves but smaller, limited to base of spike: antheridia in pairs.

Type-locality, Salem, North Carolina (Schweinitz).

On rocks and trees. Connecticut (Hall, Evans); New York (Peck); Pennsylvania (James, Lea); Delaware (James, Commons); District of Columbia (Coville, Holzinger); Virginia (Mrs. Britton and Miss Vail); West Virginia (Millspaugh); North Carolina (Schweinitz); South Carolina (Green); Tennessee (Underwood); Georgia (Underwood, Small); Alabama (Mohr); Mississippi (Lloyd and Tracy); Missouri (Russell); Arkansas (Coville); Louisiana (Langlois).

EXSIC.: Musc. Alleg. 262 (as *Phragmicoma clypeata*). Hep. Bor.-Amer. 95 (as *Phragmicoma clypeata*). Hep. Amer. 50 *p.p.* (as *Lejeunea* (*Archi-Lej.*) *clypeata*).

Archilejeunea clypeata and the two following species are very closely related. They differ from typical members of the genus in their pale color, less robust habit and short antheridial spikes. In these peculiarities they show an approach to the genus *Cheilolejeunea*, from which their undivided underleaves should probably exclude them. Recent writers on the hepaticae, however, tend to ascribe less value to this character than was originally done by Spruce, and species with undivided underleaves have been described in the genera *Euosmolejeunea*, *Cheilolejeunea* and *Pycnolejeunea*. Under these circumstances the generic position of *A. clypeata* and its immediate allies cannot be regarded as thoroughly established.

In studying *A. clypeata*, the writer has been able to examine the type of *Jungermannia clypeata* from the Schweinitz herbarium, the type of *Lejeunea Dorotheae* from the Lindenberg herbarium and a portion of the type of *L. calyculata* from the Taylor herbarium. The specimens in the Schweinitz herbarium labeled *Jungermannia transversalis* have also been examined, as well as the plants which Schweinitz sent to Torrey under this name. All of these various specimens evidently belong to the same species. In *L. Dorotheae* and in the plants labeled *J. transversalis*, the apex of the lobule

is sometimes composed of two superposed cells, instead of a single cell as is usual in the species. They show, however, even on robust stems, no other approach to either of the following species.

2. ARCHILEJEUNEA SELLOWIANA Steph.

PLATE 16, FIGS. 12-20

Phragmicoma xanthocarpa Aust. Hep. Bor.-Amer. 95 b. 1873. Not *Jungermannia xanthocarpa* Lehm. & Lindenb.; Lehmann, Pugillus, **5**: 8. 1832 (*Lejunea xanthocarpa* Lehm. & Lindenb.; G. L. & N. Syn. Hep. 330. 1845).

Archilejeunea Sellowiana Steph. Hedwigia, **34**: 62. 1895.

Lejeunea velata Gottsche; Stephani, *l. c.* (as synonym).

Pale glaucous-green or whitish, growing in broad depressed mats: stems prostrate, often radiating from a center, 0.17 mm. in diameter, closely appressed to matrix, irregularly branched: rhizoids abundant: leaves closely imbricated, the lobe widely spreading almost at right angles with axis, ovate-oblong, sometimes slightly falcate, plane or slightly convex, 1.2 mm. long and 0.95 mm. wide on robust individuals, slightly revolute at the rounded apex, margin entire or subcrenulate from projecting cells, antical margin rounded at base and arching across or just beyond axis; lobule somewhat inflated toward base, oblong, 0.6 mm. long, 0.25 mm. wide, keel slightly arched, forming a distinct but very obtuse angle with postical margin, free margin curved, slightly inflexed near base, otherwise plane, apex acuminate, sometimes hamately curved, the apical tooth mostly three to eight cells long and two to four cells wide at base, ending in a single row of two or three cells, sinus beyond apex deep and rounded then passing very obliquely into postical margin, free margin of lobule, except for apical tooth usually entire but, in rare cases, bearing one or two supplementary teeth between base and apex or between apex and end of keel, lobules on small branches often poorly developed; cells of lobe convex with rather thick projecting walls and thin vertical walls, trigones large, acuminate to obtuse, intermediate thickenings not infrequent in middle of lobe and abundant toward base, mostly circular in outline, cells at edge of lobe 12 μ in diameter, in the middle and at the base 18 μ: underleaves contiguous to imbricated, broadly orbicular to reniform, 0.6 mm. long, 0.7 mm. wide, rounded, truncate or retuse at the apex, rounded or subcordate at base, attached by a slightly curved line of insertion: inflorescence autoicous: ♀ inflorescence usually borne on a short branch, more rarely on a leading branch, inno-

vating one side, the innovation simple and sterile; bracts complicate, unequally bifid, sometimes with a narrow and rudimentary wing along keel, the lobe oblong-ovate to obovate, suberect to widely spreading, rounded at the apex, 0.9 mm. long, 0.6 mm. wide, lobule oblong, rounded to subacute, 0.5 mm. long, 0.2 mm. wide; bracteole oblong to obovate, 0.5 mm. long, 0.45 mm. wide, narrowed toward base, truncate at the apex; perianth obovoid, about half exserted, 0.9 mm. long, 0.7 mm. wide, cuneate toward base, broad and truncate above and with a short, narrow beak, lateral keels sharp, antical keel short and low, postical keel long, broad and prominent, sharply two-angled when young and sometimes showing a short supplementary fold between the angles near apex, keels slightly roughened from projecting cells: ♂ spikes occupying short branches, similar to those of *A. clypeata:* spores brownish-green, angular, variable in length, with thickened walls marked by minute verruculae and small orbicular patches of low, radiating ridges, averaging 23 μ in short diameter.

Type-locality, Brazil (Sellow).

On trees and rocks: Rhode Island (Bennett); Delaware Commons); Virginia (Seymour, Mears); North Carolina (Johnson); South Carolina (Miss DuBois); Tennessee (Ruth, Scoville); Georgia (Underwood); Florida (Austin, Farlow, Lighthipe, Underwood, Straub, Nash); Alabama (Mohr, Earle and Baker, Maxon and Pollard); Mississippi (Hall, Lloyd and Tracy); Louisiana (Langlois); Texas (Mohr).

EXSIC.: Hep. Bor.-Amer. 95 b (as *Phragmicoma xanthocarpa*).

A. Sellowiana was first distinguished from *A. clypeata* by Austin, who considered it identical with *Lejeunea xanthocarpa* Lehm. & Lindenb., a widely distributed tropical and subtropical species occurring in both America and Africa. Austin distributed the plant as *Phragmicoma xanthocarpa* and it has since been known in America under this name. Through the kindness of Stephani, the writer has been enabled to study a specimen of *A. Sellowiana* collected at Petropolis, Brazil, by Rudolph. This specimen, which is quoted immediately after the type in the original description, agrees very closely with the specimens from the United States. It is probable, therefore, that the range of the species extends through Mexico and Central America into Brazil. It is worthy of note that the sterile type-specimens, collected by Sellow, were first referred doubtfully by Stephani to *A. clypeata.**

* Hedwigia, 29: 20. 1890.

Austin incorrectly referred to his "*Phragmicoma xanthocarpa*," as synonyms, *Jungermannia transversalis* Schweinitz and *Lejeunea catenulata* Nees.* The first of these has already been commented upon. The second is a distinct species of the genus *Neurolejeunea*,† and its presence in the United States has not been definitely established. According to the synopsis it was found in "*Hymenophyllo ciliato* et *Neckera abietina* Hook. Americae septentrionalis." Unfortunately the genus *Hymenophyllum* is not known from the United States, *H. ciliatum* itself being found in tropical America. *Neckera abietina* (*Alsia abietina* Sull.), on the other hand, is found in California and northward along the Pacific coast, a region from which no Lejeuneae have been recorded except the recently described *Cololejeunea Macounii* of British Columbia. Under the circumstances we must exclude *Neurolejeunea catenulata* from our list.

The most important differences between *A. Sellowiana* and *A. clypeata* are drawn from their vegetative organs. *A. Sellowiana* is the more robust of the two species; the lobes of its leaves spread more widely and are at the same time more falcate; the lobule is oblong instead of ovate-triangular in outline, and its apex is acuminate instead of apiculate; the cells of the lobe have more conspicuous trigones and more numerous intermediate thickenings, the latter being practically absent in *A. clypeata;* its much broader underleaves finally are more crowded together and are usually subcordate at the base. The perichaetial bracts and perianths are so variable in both species that the slight differences between them are of little diagnostic value. In *A. Sellowiana*, however, the female flower is usually borne on a short branch, while in *A. clypeata* it is usually borne on a leading branch. Unfortunately even this difference is inconstant. The perigonial spikes are essentially the same in both species.

In the true *A. xanthocarpa* (Lehm. & Lindenb.) Steph., the lobe is much more strongly convex than in *A. Sellowiana*, and the margin is revolute both at the apex and along the entire postical side. In the lobule also the free margin is strongly involute for the greater part of its length. The leaf-cells are similar in the two

* Syn. Hep. 323. 1845.

† Spruce, Hep. Amaz. et And. 84. 1884; Schiffner; Engler & Prantl, Nat. Pflanzenfam. 1^3: 131. 1893.

species, but intermediate thickenings in *A. xanthocarpa* are very infrequent.

3. **Archilejeunea conchifolia** sp. nov.

PLATE 17, FIGS. 1–9

Pale yellowish-green or whitish, growing in depressed mats: stems prostrate, 0.1 mm. in diameter, closely appressed to matrix, irregularly branched: rhizoids abundant: leaves densely imbricated, the lobe obliquely spreading, not falcate, ovate, very convex, 0.7 mm. long, 0.45 mm. wide, strongly revolute at the rounded apex and along the postical margin, antical margin slightly rounded at base, arching across or just beyond axis, margin entire or very vaguely and sparingly crenulate; lobule inflated, oblong, 0.45 mm. long, 0.17 mm. wide, keel more or less arched, usually forming a continuous line with the revolute postical margin but sometimes slightly indented at junction with postical margin, free margin curved, involute to or beyond apex, sinus beyond apex deep and rounded then passing very obliquely into the revolute postical margin, apex acuminate, the apical tooth mostly three to six cells long and three or four cells wide at base, ending in a single row of two or three cells; cells of lobe slightly papillose, with thickened free walls and thin vertical walls, trigones small, intermediate thickenings very scanty near base of lobe, otherwise wanting, cells at edge of lobe 14 μ in diameter, in the middle and at the base 20 μ: underleaves contiguous or imbricated, broadly orbicular, 0.25 mm. long, 0.35 mm. wide, broadly truncate at the apex, abruptly narrowed and neither rounded or truncate at base, very shortly decurrent and attached by a slightly curved line of insertion: inflorescence autoicous: ♀ inflorescence usually borne on a leading branch, rarely on a short branch, innovating on one side, the innovation usually short, simple and sterile; bracts complicate, shortly and unequally bifid, not winged on keel, the lobe ovate, obliquely or widely spreading, rounded at the apex, entire, 0.7 mm. long, 0.45 mm. wide, lobule narrowly ovate to lingulate, obtuse to acute at the apex, 0.45 mm. long, 0.17 mm. wide; bracteole obovate, 0.5 mm. long, 0.35 mm. wide, narrowed toward base, truncate or slightly retuse at the broad apex; perianth obovoid, about half exserted, 0.85 mm. long, 0.5 mm. wide, cuneate toward base, rounded or truncate above and with a short beak, lateral keels sharp, antical keel distinct, about half as long as perianth, postical keel long, broad and sharply two-angled when young, keels smooth or nearly so: ♂ spikes occupying short branches, similar to those of *A. clypeata*.

Type-locality, Orange Bend, Florida (Underwood, 60).

On trees. South Carolina (Ravenel, Miss Du Bois); Alabama (Baker); Florida (Underwood).

EXSIC.: Hep. Amer. 50 *p. p.* (as *Lejeunea* (*Archi-Lej.*) *clypeata*).

A. conchifolia is of about the same size as *A. clypeata*, and agrees with it in the position of its female flowers. It differs in its obliquely spreading, convex lobes with revolute apex and margin, in its oblong lobule with acuminate apex and in its imbricated underleaves, usually broader than long. From *A. Sellowiana* it differs mainly in its smaller size and in the characters of its convex leaf-lobes, which are not at all falcate.

A. conchifolia is perhaps closer to *A. xanthocarpa* than is the preceding species, agreeing with it in its convex leaf-lobes with revolute postical margins. It is, however, much less robust, its lobes spread more obliquely, its lobules are relatively larger and their apices can usually be made out without dissection.

4. MASTIGOLEJEUNEA AURICULATA (Wils. & Hook.) Schiffn.

PLATE 17, FIGS 10-19

Jungermannia auriculata Wils. & Hook.; Drummond, Musc. Amer. St. Merid. 170. 1841.

Phragmicoma versicolor Lehm. & Lindenb. *p. p.*; G. L. & N. Syn. Hep. 297. 1845.*

Phragmicoma teretiuscula Lindenb. & Gottsche, *p. p.*, *l. c.* 745. 1847.

Lejeunea auriculata Sull.; Gray, Manual, Ed. II., 699. 1856.

Ptycocoleus auriculatus Trevis. Mem. r. Ist. Lomb. III. 4: 405. 1877.

* *Phragmicoma versicolor* of the Synopsis Hepaticarum is based on specimens collected at Madras by Wight and on Drummond's Louisiana specimens, the type of *Jungermannia auriculata* Wils. & Hook. In the supplement to this work, the authors refer some of Wight's specimens to *P. repleta* Tayl. (Lond. Jour. Bot. 5: 392. 1846) and the remainder to the newly described *P. teretiuscula* Lindenb. & Gottsche (p. 745), in which certain Mexican specimens collected by Liebman are also included. This last species, according to Stephani (Hedwigia, 29: 8. 1890), is also a composite, the Indian specimens being referable to *P. ligulata* Lehm. & Lindenb. (Syn. Hep. 301) and the Mexican specimens to *P. versicolor*. It is evident from the above notes that the name "versicolor," although finally restricted by the authors of the Synopsis to Drummond's specimens, cannot justly supersede the older name "auriculata." According to the strict rules of priority, however, it might still be made to replace the name "repleta" of Taylor, but apparently there is enough reason for giving it up altogether. Of course the name "teretiuscula" has no claims whatever.

Lejeunea (*Mastigo-Lejeunea*) *auriculata* Spruce, Hep. Amaz. et And. 102. 1884.

Mastigolejeunea auriculata Schiffn.; Engler & Prantl, Nat. Pflanzenfam. I[3]: 129. 1893.

Glaucous green, varying to brownish or purplish in older parts, growing in depressed tufts: stems prostrate or pendent, 0.15 mm. in diameter, arising from a creeping caudex, irregularly pinnate or on ♀ plants rarely dichotomous, branches widely spreading, sometimes small-leaved and flagelliform: rhizoids scanty: leaves densely imbricated, closely appressed when dry, widely spreading and subsquarrose when moist, the lobe ovate-oblong, more or less falcate, 1 mm. long, 0.5 mm. wide, apex usually obtuse, sometimes rounded or subacute, margin entire or subrepand, antical margin rounded to auriculate at base, postical margin more or less revolute, especially on robust axes; lobule more or less inflated, very variable, averaging 0.35 mm. long and 0.2 mm. wide, on small branches ovate, the free margin more or less rounded, somewhat involute, apex apiculate, acute or obtuse, sinus beyond apex broad and shallow, passing very obliquely into postical margin of lobe, lobule on robust stems and branches often appearing simply as a broadening out of the postical margin of lobe, without showing a distinct apex, these two extreme types of lobule being connected by intermediate conditions, hexagonal or subrhomboid in outline; cells of lobe plane, thick-walled and with distinct trigones, intermediate thickenings occasionally present toward base of lobe, cells at edge of lobe 8 μ in diameter, in the middle 21 × 12 μ, at the base 23 × 14 μ: underleaves imbricated, broadly orbicular, 0.5 mm. long, 0.55 mm. wide, with a broad, median ridge, truncate or slightly retuse at apex, cuneate toward base, indistinctly decurrent or minutely auriculate at base and attached by a slightly curved line of insertion, margin irregularly sinuate, more or less revolute at apex and near base: inflorescence autoicous or dioicous: ♀ inflorescence borne on a leading branch, innovating on one or rarely on both sides, the innovations once or repeatedly floriferous; bracts complicate, unequally bifid, the lobe ovate, suberect to widely spreading, 1.2 mm. long, 0.6 mm. wide, the apex usually subacute, but varying from rounded to acuminate, margin irregularly sinuous, lobule oblong to obovate, bluntly pointed, truncate or retuse at apex, 0.7 mm. long, 0.35 mm. wide; bracteole 0.8 mm. long, 0.7 mm. wide, obovate from a slightly narrowed base, at the apex rounded, truncate, retuse or emarginate with a lunulate sinus, margin sinuous, more or less revolute toward base; perianth oval in outline, about one third exserted, 1.5 mm. long, 0.6 mm. wide, rounded at base and at apex, beak short and broad, strongly compressed and

with a high, narrow, postical keel, antical surface plane or nearly so, keels not winged: ♂ inflorescence borne on ♀ plants, occupying ordinary branches or innovations, usually proliferating and sometimes repeatedly floriferous; bracts in six to twelve pairs, similar to the leaves, but with smaller, less widely spreading lobes, more strongly arched keels and larger, more inflated lobules, truncate to retuse at apex; bracteoles similar to underleaves, found throughout spike; antheridia borne singly: spores greenish, thick-walled, minutely verruculose, averaging 34 μ in short diameter.

Type-locality, New Orleans and Louisiana (Drummond).

On trees. Florida (J. D. Smith, Underwood, Straub); Alabama (Mohr); Louisiana (Drummond, Langlois). The species is widely distributed in tropical America.

EXSIC.: Musc. Amer. St. Merid. 170 (as *Jungermannia auriculata*). Hep. Amer. 133 (as *Lejeunea* (*Mastigo-Lej.*) *auriculata*).

Mastigolejeunea auriculata belongs to a tropical and subtropical genus which has no other known representatives in the United States. The species bears, however, a certain superficial resemblance to *Brachiolejeunea corticalis*, with which it has been confused. The latter species is readily distinguished by its crenulate lobules, larger leaf-cells, usually double innovation and pluriplicate perianth.

According to Spruce,* *M. auriculata* can scarcely be distinguished from the Javan *M. humilis* (Gottsche) Schiffn., to which he would also reduce M. *repleta* (Tayl.). Stephani † states that all three species are amply distinct. The writer has examined a specimen of *M. humilis* and finds that this species, although very close to *M. auriculata*, differs in its smaller size, in its much less variable lobule, which ends in a long outwardly curved tooth consisting of three or eight cells in a single row, in its more emarginate underleaves and in the broader lobes and lobules of its perichaetial bracts. According to Stephani *M. repleta* is distinguished by its apiculate leaves.

5. BRACHIOLEJEUNEA CORTICALIS (Lehm. & Lindenb.) Schiffn.

PLATE 18, FIGS. 1–11

Jungermannia corticalis Lehm. & Lindenb.; Lehmann, Pugillus, **4**: 50. 1832.

* Hep. Amaz. et And. 103. 1884.

† Hedwigia, **29**: 9. 1890.

Frullania Leprieurii Nees & Mont.; Mont. Ann. des Sc. Nat. II. **14**: 333. *pl. 20. f. 1.* 1840.

Phragmicoma corticalis Lehm. & Lindenb.; G. L. & N. Syn. Hep. 297. 1845.

Phragmicoma melanophloea Mont. & Nees, *l. c.* 297 (as synonym).

Lejeunea linguaefolia Tayl. Lond. Jour. Bot. **5**: 390. 1846. G. L. & N. Syn. Hep. 754. 1847 (*fide* Stephani).

Phragmicoma Leprieurii Mont. Sylloge, 86. 1856.

Ptychocoleus corticalis Trevis. Mem. r. Ist. Lomb. III. **4**: 405. 1877.

Lejeunea (*Brachio-Lejeunea*) *corticalis* Steph. Hedwigia, **29**: 8. 1890.

Brachiolejeunea corticalis Schiffn. Hedwigia, **33**: 180. 1894 (in obs.).

Brownish-green, growing in depressed tufts, ♂ and ♀ plants mixed together: stems prostrate, appressed to substratum, 0.2 mm. in diameter, irregularly pinnate or on ♀ plants more or less dichotomous, branches never flagelliform, widely spreading but at less than a right angle: rhizoids often abundant: leaves imbricated, more or less appressed when dry, widely spreading when moist, the lobe ovate, falcate, 0.85 mm. long, 0.5 mm. wide, apex broad, rounded or very obtuse, margin entire, antical margin curved, arching across axis and rounded or subcordate at base, postical margin distinctly indented beyond end of keel; lobule strongly inflated about half its width, broadly ovate, measuring, when inflated, 0.45 mm. long and 0.25 mm. wide, keel straight or slightly arched, subcrenulate from projecting cells, free margin plane and appressed to lobe, rounded at inner edge, then straight or slightly curved and passing obliquely into postical margin of lobe, usually bearing four scattered papilla-like teeth, each consisting of a single blunt cell or rarely of two cells, and, near outer end, a fifth angular tooth, the last sometimes obsolete; cells of lobe plane or somewhat papillose, thin-walled, trigones distinct, usually with two convex sides and one concave side, intermediate thickenings very infrequent, cells at edge of lobe 13 μ in diameter, in the middle 23 × 16 μ, at the base 28 × 23 μ: underleaves slightly imbricated, orbicular-quadrate to reniform, 0.45 mm. long, 0.45 mm. wide, truncate or retuse at the broad apex, sides parallel or converging toward base: inflorescence dioicous: ♀ inflorescence borne on a leading branch, usually innovating on both sides, more rarely on one side, the innovations usually once or twice floriferous; bracts complicate, unequally bifid,

keel broadly winged in lower half, the wing entire, semicircular to semiovate in outline, lobe ovate, obliquely spreading, rounded at apex, subcordate at base, irregularly sinuous on margin, 0.95 mm. long, 0.5 mm. wide, lobule lanceolate-ligulate, rounded at apex, sinuous on margin, 0.85 mm. long, 0.2 mm. wide; bracteole free, oblong, 0.85 mm. long, 0.4 mm. wide, truncate to retuse at apex, broadening out slightly toward base, irregularly sinuous on margin; perianth oblong-obovoid, about one third exserted, 1.1 mm. long, 0.6 mm. wide, rounded at apex and with a short, broad beak, somewhat compressed in upper half with sharp lateral keels, postical keel broad, sharply two-angled and with a short, supplementary fold near apex, antical keels one to three, low and short: ♂ spikes spikes borne on leading branches, usually proliferating and repeatedly floriferous, bracts in about six pairs, less spreading than the leaves, the lobe not falcate, lobule nearly as long as lobe but narrower, inflated, apex blunt to subacute, margin entire; bracteoles similar to underleaves, found throughout spike.

Type-locality, Jamaica (Herb. Lehm. & Lindenb.).

On trees. Lake Worth, Florida (Underwood). The species has a rather wide distribution in tropical America.

Brachiolejeunea corticalis has not before been recorded from the United States. The Florida specimens, however, agree closely with the type and also with the specimens from Cuba, distributed in Hep. Amer. 144. There is no danger of confusing the species with any of our other Lejeuneae except possibly *Mastigolejeunea auriculata*, under which the most important differences have already been enumerated.

The genus *Brachiolejeunea* has several representatives in tropical America, and among them *B. bicolor* (Nees) Schiffn. is perhaps most closely related to *B. corticalis*. *B. bicolor* is a more robust plant, the lobes of its leaves tend to be more sharply pointed, its underleaves are more or less auriculate at base and its perianth is regularly pluriplicate, usually with ten distinct folds in the upper part.

6. HARPALEJEUNEA OVATA (Hook.) Schiffn.

Jungermannia serpyllifolia β ovata Hook. Brit. Jung. 1816 (not figured).

Lejeunea ovata Tayl.; G. L. & N. Syn. Hep. 376. 1845.

Lejeunea (*Harpa-Lejeunea*) *ovata* Spruce, Hep. Amaz. et And. 165. 1884.

Frullania Leprieurii Nees & Mont.; Mont. Ann. des Sc. Nat. II. **14**: 333. *pl. 20. f. 1.* 1840.

Phragmicoma corticalis Lehm. & Lindenb.; G. L. & N. Syn. Hep. 297. 1845.

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Phragmicoma Leprieurii Mont. Sylloge, 86. 1856.

Ptychocoleus corticalis Trevis. Mem. r. Ist. Lomb. III. **4**: 405. 1877.

Lejeunea (*Brachio-Lejeunea*) *corticalis* Steph. Hedwigia, **29**: 8. 1890.

Brachiolejeunea corticalis Schiffn. Hedwigia, **33**: 180. 1894 (in obs.).

Brownish-green, growing in depressed tufts, ♂ and ♀ plants mixed together: stems prostrate, appressed to substratum, 0.2 mm. in diameter, irregularly pinnate or on ♀ plants more or less dichotomous, branches never flagelliform, widely spreading but at less than a right angle: rhizoids often abundant: leaves imbricated, more or less appressed when dry, widely spreading when moist, the lobe ovate, falcate, 0.85 mm. long, 0.5 mm. wide, apex broad, rounded or very obtuse, margin entire, antical margin curved, arching across axis and rounded or subcordate at base, postical margin distinctly indented beyond end of keel; lobule strongly inflated about half its width, broadly ovate, measuring, when inflated, 0.45 mm. long and 0.25 mm. wide, keel straight or slightly arched, subcrenulate from projecting cells, free margin plane and appressed to lobe, rounded at inner edge, then straight or slightly curved and passing obliquely into postical margin of lobe, usually bearing four scattered papilla-like teeth, each consisting of a single blunt cell or rarely of two cells, and, near outer end, a fifth angular tooth, the last sometimes obsolete; cells of lobe plane or somewhat papillose, thin-walled, trigones distinct, usually with two convex sides and one concave side, intermediate thickenings very infrequent, cells at edge of lobe 13 μ in diameter, in the middle 23 × 16 μ, at the base 28 × 23 μ: underleaves slightly imbricated, orbicular-quadrate to reniform, 0.45 mm. long, 0.45 mm. wide, truncate or retuse at the broad apex, sides parallel or converging toward base: inflorescence dioicous: ♀ inflorescence borne on a leading branch, usually innovating on both sides, more rarely on one side, the innovations usually once or twice floriferous; bracts complicate, unequally bifid,

keel broadly winged in lower half, the wing entire, semicircular to semiovate in outline, lobe ovate, obliquely spreading, rounded at apex, subcordate at base, irregularly sinuous on margin, 0.95 mm. long, 0.5 mm. wide, lobule lanceolate-ligulate, rounded at apex, sinuous on margin, 0.85 mm. long, 0.2 mm. wide; bracteole free, oblong, 0.85 mm. long, 0.4 mm. wide, truncate to retuse at apex, broadening out slightly toward base, irregularly sinuous on margin; perianth oblong-obovoid, about one third exserted, 1.1 mm. long, 0.6 mm. wide, rounded at apex and with a short, broad beak, somewhat compressed in upper half with sharp lateral keels, postical keel broad, sharply two-angled and with a short, supplementary fold near apex, antical keels one to three, low and short: ♂ spikes spikes borne on leading branches, usually proliferating and repeatedly floriferous, bracts in about six pairs, less spreading than the leaves, the lobe not falcate, lobule nearly as long as lobe but narrower, inflated, apex blunt to subacute, margin entire; bracteoles similar to underleaves, found throughout spike.

Type-locality, Jamaica (Herb. Lehm. & Lindenb.).

On trees. Lake Worth, Florida (Underwood). The species has a rather wide distribution in tropical America.

Brachiolejeunea corticalis has not before been recorded from the United States. The Florida specimens, however, agree closely with the type and also with the specimens from Cuba, distributed in Hep. Amer. 144. There is no danger of confusing the species with any of our other Lejeuneae except possibly *Mastigolejeunea auriculata*, under which the most important differences have already been enumerated.

The genus *Brachiolejeunea* has several representatives in tropical America, and among them *B. bicolor* (Nees) Schiffn. is perhaps most closely related to *B. corticalis*. *B. bicolor* is a more robust plant, the lobes of its leaves tend to be more sharply pointed, its underleaves are more or less auriculate at base and its perianth is regularly pluriplicate, usually with ten distinct folds in the upper part.

6. HARPALEJEUNEA OVATA (Hook.) Schiffn.

Jungermannia serpyllifolia β ovata Hook. Brit. Jung. 1816 (not figured).

Lejeunea ovata Tayl.; G. L. & N. Syn. Hep. 376. 1845.

Lejeunea (*Harpa-Lejeunea*) *ovata* Spruce, Hep. Amaz. et And. 165. 1884.

Lejeunea Molleri Steph. Hedwigia, **26**: 3. *pl. 1. f. 2.* 1887.

Harpalejeunea ovata Schiffn.; Engler & Prantl, Nat. Pflanzenfam. **I**^{3}: 127. 1893.

Pale to dark green, loosely depressed-caespitose or scattered among other hepatics: stems prostrate, 0.05 mm. in diameter, closely appressed to substratum, irregularly branched: rhizoids few: leaves contiguous or somewhat imbricated, the lobe convex, obliquely to widely spreading, falcate-ovate, 0.3 mm. long, 0.15 mm. wide, gradually narrowed beyond middle, apex often reflexed, mostly acute or short-acuminate, rarely obtuse, margin subentire or irregularly sinuate, antical margin curved, arching part way across axis and almost straight at base, postical margin slightly rounded near keel and forming with it a distinct angle varying from obtuse to acute; lobule strongly inflated, ovoid, 0.15 mm. long, 0.08 mm. wide, keel strongly arched, crenulate from convex cells, free margin slightly curved, involute to beyond apex, then obliquely truncate or lunulate to end of keel, apex tipped with a single, projecting cell, curving slightly outwards or nearly straight; cells of lobe convex, thin-walled, trigones distinct though sometimes minute, intermediate thickenings scattered, usually distinct, basal ocelli formed of two to five enlarged, thin-walled cells, cells at edge of lobe averaging 14 μ in diameter and in the middle 18 μ, cells of ocelli 30 × 24 μ: underleaves distant, broadly cuneiform, 0.08 mm. long, 0.1 mm. wide, lateral margins straight or nearly so near base, apex broad, truncate or usually emarginate-obcordate with a shallow sinus and broad, rounded or very obtuse segments, usually three to five cells long and four or five cells broad at base, margin entire: inflorescence dioicous: ♀ inflorescence on a leading branch, innovating on one or rarely on both sides, the innovations usually simple andsterile; bracts complicate, unequally bifid, sometimes narrowly winged along keel, the wing often interrupted, one or two cells wide, lobe suberect, oblong to obovate, 0.5 mm. long, 0.25 mm. wide, gradually narrowed toward the obtuse or rounded apex, often bearing scattered ocelli, lobule narrowly oblong-ovate, rounded or truncate at apex, 0.4 mm. long, 0.15 mm. wide, margins of bracts entire, bracteole slightly connate on both sides, oblong-ovate to broadly obovate, 0.3 mm. long, 0.2 mm. wide, rounded to emarginate-bifid at apex with rounded segments, sometimes sparingly ocellate, margin entire; perianth obovate-clavate, acutely five-keeled in upper part: ♂ spike occupying a short branch; bracts in one or two pairs, closely imbricated, erect, unequally bilobed, antical lobe oval, obtuse, postical lobe similar but smaller.

Type-locality, Ireland (Taylor).

On trees and fallen logs. Southern States (Sullivant, fide Austin); Virginia (Mrs. Britton and Miss Vail); Tennessee (Ruth); Georgia (Underwood). The species also occurs in western Europe but is rare. Pearson * states that it grows on shaded rocks but according to Camus † it is also found on bark.

Harpalejeunea ovata has been illustrated three times within recent years. Stephani's figure, already noted in the synonymy, was drawn from specimens collected in Portugal. The writer has illustrated the specimens from Virginia,‡ while Pearson has published figures drawn from British material.§ The perianth, known only from the brief description in the Synopsis Hepaticarum, does not appear in any of these illustrations.

The American specimens agree closely with the type-material in the Taylor herbarium but show a greater variability in the shape of the bracteole than European writers describe. There are no male specimens among them, and the description given above of the perigonial spike is taken wholly from Pearson.

There is no other species from the United States with which *H. ovata* ought to be confused. The acute lobes of its leaves and its emarginate-bifid underleaves with rounded divisions are unique among our Lejeuneae. The species, however, finds several close allies in tropical regions, where the genus *Harpalejeunea* is largely represented.

7. **Euosmolejeunea duriuscula** (Nees)

PLATE 18, FIGS. 12–13

Jungermannia serpyllifolia Wils. & Hook. *p. p.* Drummond, Musc. Amer. St. Merid. 171. 1841.

Lejeunea duriuscula Nees; G. L. & N. Syn. Hep. 364. 1845.

Lejeunea flexuosa Lindenb. *l. c.* 385. 1845 (*fide* Stephani).

Lejeunea serpyllifolia var. Sull. Musc. Alleg. 273. 1845.

Lejeunea Sullivantiae Aust. Bull. Torrey Club, **3**: 15. 1872.

Lejunea Austini Lindb. Acta Soc. Sci. Fenn. **10**: 489. 1875.

Lejeunea (*Cheilo-Lejeunea*) *duriuscula* Spruce, Hep. Amaz. et And. 259. 1884.

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* Hep. Brit. Isles, 43. 1899.

† Bull. Soc. Bot. de France, **47**: 201. 1900.

‡ Small & Vail, Mem. Torrey Club, **4**: *pl. 81.* 1894.

§ *L. c. pl. 8.*

Lejeunea (*Eulejeunea*) *duriuscula* Steph. Hedwigia, 29: 80. 1890.

Lejeunea (*Eu-Lejeunea*) *Underwoodii* Steph. Bot. Gazette, 17: 171. 1892.

Cheilolejeunea duriuscula Schiffn.; Engler's Bot. Jahrb. 23: 592. 1897 (in obs.).

Yellowish-green, sometimes tinged with brownish, depressed-caespitose: stems prostrate, loosely appressed to substratum, 0.08 mm. in diameter, sparingly and irregularly branched: rhizoids scanty: leaves slightly imbricated, the lobe convex, obliquely to widely spreading, falcate-ovate, 0.4 mm. long, 0.35 mm. wide, rounded or very obtuse at the apex, margin slightly and irregularly angular-sinuate, antical margin arching across or just beyond axis, rounded at base, postical margin forming an obtuse angle with keel; lobule strongly inflated, triangular-ovate, measuring when inflated 0.1 mm. long, 0.08 mm. wide, keel slightly arched or almost straight, somewhat decurrent, free margin strongly involute to beyond the obtusely pointed or apiculate apex, then obliquely truncate to end of keel; cells of lobe plane or slightly convex, with somewhat thickened walls and large, triangular trigones, averaging 13 μ in diameter at edge of lobe, 16 μ in the middle and 21 μ at base: underleaves distant, ovate to orbicular, 0.17 mm. long, 0.15 mm. wide, bifid about one half with acute, slightly spreading lobes and narrow usually acute sinus, cuneate and slightly decurrent at base, sometimes very minutely auriculate: inflorescence dioicous: ♀ inflorescence borne on a leading branch, innovating on one or sometimes on both sides, the innovations long, often floriferous; bracts complicate, unequally bifid, the lobe suberect to widely spreading, ovate to falcate-ovate, rounded to obtuse at the apex, margin as in leaves, 0.5 mm. long, 0.3 mm. wide, lobule ovate to lanceolate, rounded to acuminate at the apex, 0.17 mm. long, 0.08 mm. wide; bracteole free, broadly ovate to obovate, 0.45 mm. long, 0.35 mm. wide, bifid about one third with erect, acute lobes and narrow, mostly acute sinus; perianth brownish, somewhat exserted, obovoid, 0.8 mm. long, 0.5 mm. wide, rounded, truncate or slightly retuse at apex and with a short beak, somewhat compressed with sharp lateral keels and a broad, sharply two-angled postical keel, antical keel lower, surface smooth: ♂ spike borne on a leading branch or rarely on a short branch, usually proliferating at the apex; bracts in two to four pairs, very concave and strongly inflated, shortly and subequally bifid with a strongly arched keel and rounded or obtuse lobes, slightly crenulate at apex; bracteoles similar to underleaves but smaller, present only in lower part of spike.

Type-locality, Surinam (Curie).

On trees or rotten logs, often growing with mosses or other hepatics. Florida (J. D. Smith, Farlow, Underwood); Alabama (Sullivant, Mohr); Mississippi (Langlois, Lloyd and Tracy); Louisiana (Drummond, Featherman, Langlois, Faxon). The species has a wide distribution in tropical America.

EXSIC.: Musc. Amer. St. Merid. 171 *p. p.* (as *Jungermannia serpyllifolia*). Musc. Alleg. 273 (as *Lejeunea serpyllifolia* var.). Hep. Bor.-Amer. 96 (as *Lejeunea Sullivantiae*). Hep. Amer. 135 (as *Lejeunea* (*Eu-Lej.*) *Underwoodii*).

Lejeunea Sullivantiae Aust. has been more or less of a puzzle to hepaticologists, and yet the original description, although brief, is not misleading. The specimens distributed by Austin and by Sullivant, moreover, are both abundant and characteristic. Unfortunately Austin makes no note in his description of the female flowers, although they are fairly abundant in the material which he studied. The probability is that he overlooked them because they had developed no perianths.

A few years after *L. Sullivantiae* was published, Lindberg studied the specimens in Musc. Alleg. 273 and Hep. Bor.-Amer. 96 and proved that they were identical with the dark tufts in No. 171 of Drummond's exsiccata. He also stated that they could not be distinguished from *L. thymifolia* Nees, ?γ of the Synopsis Hepaticarum,* a plant which he knew from male specimens collected in French Guiana by Leprieur. *L. thymifolia* has since been reduced to *L. flava* Swartz,† and the questionable variety γ is referred by Stephani ‡ to *L. duriuscula*, a species with which Lindberg was apparently unfamiliar Objecting to the name "*L. Sullivantiae*" on account of the older *L. Sullivantii* Gottsche,§ Lindberg gave to Austin's species the name *L. Austini*, and presumably referred to it the var. γ, to which allusion has just been made.

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* 373.

† Spruce, Hep. Amaz. et. And. 271; Schiffner, Conspect. Hep. Arch. Ind. 249. 1898.

‡ Hedwigia, 29: 83. 1890. It should perhaps be noted that Stephani's specimens of var. γ were collected by Beyrich in Brazil and are the plants mentioned in the Synopsis. Gottsche (Mex. Leverm. 218. 1863) refers these same specimens to *L. pulvinata* Lehm. & Lindenb. (Syn. Hep. 382).

§ Mex. Leverm. 196. 1863.

The validity of *L. Austini*, so far as the specimens from the United States are concerned, is recognized both by Underwood and by Stephani. The latter author first referred it to the subgenus *Eu-Lejeunea*, but at present considers it a *Cheilolejeunea*. With it he compares his *Eu-Lejeunea Underwoodii*, from Florida, a plant which he is now also inclined to place in *Cheilolejeunea*. It is evident from the above statements that *L. duriuscula*, *L. Austini* and *L. Underwoodii* are all considered distinct species by Stephani.

The writer has examined all the specimens which Lindberg referred to *L. Austini* with the exception of those from Guiana. He has also examined the specimens of *L. Underwoodii* distributed by Underwood and Cook and those of *Euosmolejeunea duriuscula* in Hepaticae Spruceanae, collected near Pará, in Brazil. All of these plants show female flowers without perianths, and there are no male plants among them. As a result of this study it would appear that all of these specimens are referable to the same species, for which the oldest available specific name, "duriuscula," should be retained. The differences stated by Stephani in his published papers and in his manuscript notes are not always apparent and seem hardly sufficient to separate the species. He states, for example, that *L. Austini* has much smaller leaf-cells than *L. Underwoodii*, and that the lobule of the latter species is inflated and has an arched keel, whereas in *L. Austini* the lobule is not inflated and the keel is approximately straight or concavely arched. He states also that the bracteole is free in *L. Underwoodii* and slightly connate on one side in *L. Austini*. The first of these differences does not hold, since the cells of *L. Austini* average fully as large as those of *L. Underwoodii*. The second difference is unreliable, because convexly arched, straight, and concavely arched keels may often be found on a single stem, and the degree of inflation depends largely upon the degree of development. The third difference is at best inconstant as the bracteole is uniformly free in the specimens of *L. Austini* examined by the writer. Stephani has published no descriptive notes on *Euosmolejeunea duriuscula* but has kindly furnished a drawing of this species made from the type-material. This agrees essentially with the specimens distributed by Spruce. In reducing *L. Austini* and *L. Underwoodii* to synonymy the writer regrets differing from so eminent an authority as

Stephani but feels compelled to follow the evidence drawn from the specimens themselves.

Opinions have varied with regard to the systematic position of *E. duriuscula*. By Spruce it was first placed in *Cheilo-Lejeunea*, a disposition now accepted by Stephani and by Schiffner. Spruce afterwards transferred it to *Euosmolejeunea*, thereby agreeing with an earlier view of Stephani. The plant agrees with *Euosmolejeunea* in its color and general habit, in its leaves and cell-structure and in its perianth. Its underleaves, however, are smaller than is usual in the genus and lack the basal cordations which normally occur. Since several species of *Euosmolejeunea* with equally small underleaves have been described, this difference by itself should hardly suffice to exclude *E. duriuscula*. The species certainly has less in common with either *Cheilolejeunea* or *Lejeunea* proper than it has with *Euosmolejeunea*.

E. duriuscula seems to be limited with us to the States bordering the Gulf of Mexico. The specimens from Kirkville, New York, quoted by Underwood as *L. Austini* * are referable to *Lejeunea cavifolia*. These specimens were determined by Spruce, who had apparently been misled by plants incorrectly referred to *L. Austini*. In addition to *L. cavifolia*, no fewer than four of our other Lejeuneae have been found in herbaria incorrectly determined as *L. Austini*. Our only species, however, which it at all closely resembles is *Euosmolejeunea opaca*, under which the differential characters will be noted.

8. EUOSMOLEJEUNEA OPACA (Gottsche) Steph.

PLATE 19, FIGS. 1–11

Lejeunea opaca Gottsche; G. L. & N. Syn. Hep. 362. 1845.

Lejeunea (*Omphalanthus?*) *Mohrii* Aust. Bull. Torrey Club, **6**: 20. 1875.

Lejeunea (*Euosmo-Lejeunea*) *laxiuscula* Spruce, Hep. Amaz. et And. 244. 1884.

Lejeunea (*Euosmo-Lejeunea*) *opaca* Steph. Hedwigia, **29**: 79. 1890.

Euosmolejeunea opaca Steph. Bihang Svenska. Vet.-Akad. Handl. 23^2: 23. 1897.

* Bull. Torrey Club, 19: 299. 1892.

Yellowish-green, growing in depressed tufts: stems prostrate, loosely appressed to substratum, 0.1 mm. in diameter, sparingly and irregularly branched: rhizoids scanty: leaves loosely imbricated, the lobe convex, obliquely spreading, broadly ovate, 0.5 mm. long, 0.4 mm. wide, rounded at the apex, margin entire or sparingly crenulate from projecting cells, antical margin arching across or just beyond axis, rounded at the base, postical margin forming an angle a little greater than a right angle with keel; lobule strongly inflated, triangular-ovate, 0.15 mm. long, 0.1 mm. wide, keel slightly arched, free margin strongly involute to beyond the subacute apex, then obliquely truncate or lunulate to end of keel; cells of lobe plane or convex, with somewhat thickened walls and large, triangular trigones, averaging 13 μ in diameter at edge of lobe, 18 μ in the middle and 25 × 18 μ at the base: underleaves contiguous or imbricated, orbicular, 0.35 mm. long, bifid about one third with obtuse or acute, erect or subcontiguous lobes separated by an obtuse or acute sinus, rounded or cordate at base and attached by a long, curved line of insertion, margins entire: inflorescence dioicous: ♀ inflorescence borne on a short branch, innovating on one side with a short, simple innovation, very rarely without innovation; bracts complicate, unequally bifid, the lobe erect-spreading, unsymmetrically ovate, usually rounded at the apex, but varying to apiculate or acute, 0.6 mm. long, 0.35 mm. wide, lobule variable, mostly oblong and rounded at the apex, 0.17 mm. long, 0.07 mm. wide; bracteole free, orbicular to oblong, 0.45 mm. long, 0.4 mm. wide, bifid about one third with acute or subacute, erect lobes and narrow sinus; perianth about half exserted, oblong-obovoid, 0.9 mm. long, 0.45 mm. wide, gradually narrowed toward base, rounded at the apex and with a short beak, lateral keels sharp, postical keel about as long as perianth, broad and sharply two-angled, antical keel short, in upper part of perianth: ♂ spike borne on a short branch, sometimes proliferating; bracts and bracteoles similar to those of *E. duriuscula*, but the lobes of the bracts not crenulate at apex.

Type-locality, Surinam (Splitgerber).

On rotten logs. Florida (J. D. Smith, Lighthipe, Underwood, Faxon); Alabama (Mohr). Widely distributed in tropical America.

EXSIC.: Hep. Amer. 134 (as *Lejeunea* (*Euosmo-Lej.*) *trifaria*).

The abundant specimens of *E. opaca*, collected by Underwood in Florida, were at first confused with *E. trifaria* (Nees) Schiffn. This species is even more widely distributed, being found in the tropics of both hemispheres, and is certainly to be expected in the southern parts of Florida. It is a more robust plant than *E. opaca*,

and differs from it in its autoicous inflorescence and in its leaf-cells, which are more convex on the free surface of the lobe and show much more conspicuous trigones.

The type-specimens of *Lejeunea Mohrii* in the Austin herbarium are apparently referable to *E. opaca*, although sterile and in rather poor condition. They do not agree fully with Austin's description because they show bifid underleaves, but this is a character which might have been overlooked.

E. opaca differs from *E. duriuscula* in its much larger underleaves, distinctly rounded or cordate at the base, and in the position of its sexual organs, which are borne on short branches rather than on leading branches. Occasionally one meets with specimens of *E. opaca* in which the underleaves are smaller than is normal, but in such cases a careful search will commonly show underleaves of the usual size on some of the axes.

At one time Spruce * threw doubt on the validity of *E. opaca*, suspecting that it was synonymous with *Lejeunea clausa* Mont. Later he apparently changed his mind, for he distributed specimens under both of these names in his Hepaticae Spruceanae.

9. **Cheilolejeunea polyantha** sp. nov.

PLATE 19, FIGS. 12–21

Dull green or brownish, growing in depressed tufts: stems prostrate, loosely appressed to substratum, 0.1 mm. in diameter, copiously and irregularly pinnately branched, sometimes dichotomous: rhizoids scanty: leaves densely imbricated, the lobe convex, obliquely spreading, orbicular, 0.4 mm. long, rounded at the apex, margin entire or slightly and irregularly angular-sinuate, antical margin arching across axis and rounded at base, postical margin usually rounded, forming an acute or right angle with keel; lobule strongly inflated, ovoid-cylindrical, 0.12 mm. long, 0.08 mm. wide, keel slightly arched, free margin strongly involute as far as the bluntly pointed apex, then abruptly or obliquely truncate to end of keel; cells of lobe slightly convex, with somewhat thickened walls and distinct, triangular trigones, averaging 12 μ in diameter at edge of lobe, 21 μ in the middle and 23 μ at the base: underleaves imbricated, sometimes densely so, rapidly increasing in size toward a ♀ inflorescence, plane, broadly orbicular to reniform, 0.25 mm. long, 0.35 wide, bifid about one

* Hep. Amaz. et And. 245. 1884.

half the distance from apex to the strongly curved line of insertion, with broad, erect, triangular, obtuse to acute or apiculate lobes and obtuse to acute sinus, rounded to cordate at base, margin entire: inflorescence dioicous: ♀ inflorescence sometimes on a leading branch, sometimes on a short branch, innovating on one or occasionally on both sides, the innovations usually floriferous and sometimes repeatedly so, occasionally sterile; bracts complicate, deeply and unequally bifid, the lobe obliquely spreading, ovate, rounded or sometimes apiculate at apex, margins as in leaves, 0.7 mm. long, 0.4 mm. wide, lobule ovate to lanceolate, rounded to acuminate at the apex, 0.25 mm. long, 0.15 mm. wide: bracteole free, oblong-elliptical to oval, convex (postically), 0.7 mm. long, 0.5 mm. wide, bifid one fourth to one third with triangular, acute or apiculate lobes and broad obtuse to acute sinus: perianth about half exserted, obovoid, 0.85 mm. long, 0.55 mm. wide, cuneate toward base, gradually narrowed toward the rounded apex and with a short beak, antical surface plane or with a low and indistinct keel near apex, postical keel long, broad and bluntly two-angled, lateral keels slightly compressed: ♂ inflorescence not seen: spores measuring 16 μ in short diameter, elongated, irregularly angular, thick-walled, with small ridge-like thickenings, arranged radiately in circles.

On bark. Eustis, Florida (Underwood, 1380 *p.p.*), the type-locality.

Cheilolejeunea polyantha resembles to a considerable extent the South American *Pycnolejeunea papulosa* Steph.,* a species described by Spruce under the name *Lejeunea* (*Pycno-Lejeunea*) *contigua*, var. *latifolia*.† The new species, however, is much less robust than *P. papulosa*, its leaves are less convex and its leaf-cells have thinner walls and less conspicuous trigones; its underleaves are relatively longer, and its perianth has an obsolete antical keel and a longer beak.

The closely imbricated leaves and underleaves of *C. polyantha* will at once distinguish it from any of our other Lejeuneae Schizostipae, although in texture and color it somewhat resembles *Euosmolejeunea opaca* and *E. duriuscula*. From the first of these, it differs also in its more widely spreading and narrower lobules, in its broader underleaves, and in its broader perianth and perichaetial

* Hedwigia, 35: 126. 1896.

† Hep. Amaz. et And. 248. 1884. Afterwards distributed in Hep. Spruceanae as a distinct species under a manuscript name.

bracts. From the second it differs more particularly in its larger size and in its much larger underleaves, which are rounded or subcordate at the base.

10. CHEILOLEJEUNEA PHYLLOBOLA (Nees & Mont.) Schiffn.

PLATE 20, FIGS. 1–13

Lejeunea phyllobola Nees & Mont.; Ramon de la Sagra, Hist. fis. pol. y natur. Cuba, **9**: 281. 1845. G. L. & N. Syn. Hep. 369. 1845.

Lejeunea (*Hygro-Lejeunea*) *phyllobola* Steph. Hedwigia, **29**: 81. 1890.

Cheilolejeunea phyllobola Schiffn. Engler's Bot. Jahrb. **23**: 591. 1897.

Hygrolejeunea phyllobola Massal. Mem. dell' Accad. di Verona, **73**:—(33). *pl. 9. f. 12.* 1897.

Pale green, growing in depressed mats: stems prostrate, closely appressed to substratum, 0.07 mm. in diameter, irregularly and rather densely pinnate, the branches sometimes upright and flagelliform, leafless except at apex, but with well-developed underleaves: rhizoids somewhat abundant: leaves loosely imbricated, the lobe obliquely to widely spreading, orbicular-ovate, 0.5 mm. long, 0.45 mm. wide, rounded at the apex, margin entire or very slightly and irregularly sinuate from projecting cells, antical margin arching across axis, but almost straight near base, postical margin straight or slightly curved, forming a very obtuse angle with keel; lobule inflated, ovate, 0.1 mm. long, 0.07 mm. wide, keel almost straight, free margin involute to or just beyond apex, then obliquely truncate to end of keel, apex usually tipped with a single rounded cell, sometimes acute or even ending in a row of two or three cells, lobule often rudimentary and explanate; cells of lobe slightly convex, thin-walled, but with distinct trigones and occasional intermediate thickenings, the latter sometimes very scanty, measuring 10 μ in diameter at edge of lobe, 21 μ in the middle and 25 μ at base; ocelli wanting: underleaves distant, broadly ovate to orbicular, 0.17 mm. long, bifid to or beyond the middle, with narrow more or less spreading divisions and acute to lunulate sinus, the divisions rarely blunt, usually varying from rounded and apiculate to acute or acuminate, tipped with one or two cells, cuneate or slightly rounded toward base, margin subcrenulate, rarely with an angular tooth near the middle of one or both sides: inflorescence autoicous: ♀ inflorescence usually borne

on a short branch, rarely on a leading branch, innovating on one side, the short innovation sometimes sterile, sometimes bearing another ♀ or a ♂ inflorescence, rarely absent; bracts unequally bifid, complicate, the lobe widely spreading, 0.45 mm. long, 0.35 mm. wide, ovate to orbicular, more or less falcate, rounded at apex, margin as in leaves, postical margin strongly curved, lobule ovate to lanceolate, rounded to acuminate at the apex, 0.3 mm. long, 0.1 mm. wide; bracteole free, ovate, 0.35 mm. long, 0.25 mm. wide, bifid about one third with erect, acute divisions and acute sinus, margins indistinctly angular-crenulate; perianth about half exserted, obovoid but distinctly cuneate toward base with almost straight sides, 0.6 mm. long, 0.4 mm. wide, truncate or slightly retuse at the broad apex and with a short beak, antical surface plane or nearly so, lateral keels sharp, postical keel broad and bluntly two-angled: ♂ spike variable in position, sometimes intercalary or terminal on a leading branch, sometimes occupying a short branch, sometimes on an innovation; bracts in one to five pairs, strongly concave and inflated, subequally bifid with rounded lobes and a strongly arched keel: bracteoles similar to the underleaves but a little smaller, present only in lower part of spike.

Type-locality, Cuba (Herb. Montagne).

On trees. Florida (Underwood). The species is now known from several of the West Indian Islands, from Mexico and from Costa Rica. It has also lately been reported from China.

The determination of the present species is based on the specimens in Wright's Hepaticae Cubenses. These were named by Gottsche, and the determination was afterwards confirmed by Schiffner. The type specimens have not been consulted by the writer.

C. phyllobola is remarkable for the insecure way in which its side-leaves are attached to their axes, the slightest force being sometimes sufficient to break them away. As a result leafless branches are frequent, although these are much less characteristic than in *C. versifolia*. In its leaf-cells the species exhibits considerable variation, the trigones being sometimes conspicuous and sometimes difficult to demonstrate, while the intermediate thickenings are sometimes large and abundant, sometimes smaller and more scattered and sometimes wholly absent. In all the various forms the cell-measurements remain fairly constant.

C. phyllobola has been confused with *Lejeunea cavifolia*, with *Microlejeunea lucens* and even with *Enosmolejeunea duriuscula*.

From the first of these species it differs in the shape of its leaf-lobe, in its smaller lobule, in its smaller and more deeply cleft underleaves and in its more flattened perianth, the antical face being plane or nearly so. It is a much larger plant than *Microlejeunea lucens*, and differs also in its autoicous inflorescence, in the shape of its leaves, underleaves and perichaetial bracts and in its slightly larger leaf-cells, usually with more conspicuous thickenings. From *Euosmolejeunea duriuscula*, it differs in its paler color and more delicate texture, in its autoicous inflorescence, in its slightly larger leaf-cells and in the shape of its leaves and underleaves.

The species is one of those interesting links between genera which are so frequent in the Lejeuneae. Some of the reasons for placing it in *Cheilolejeunea* rather than in *Hygrolejeunea* are stated by Schiffner,* who maintains that, although the leaves and the leaf-cells show an affinity with *Hygrolejeunea*, the underleaves and perianths are more like those of *Cheilolejeunea*. Apparently Spruce was also a supporter of this view, for he described a South American hepatic under the name *L.* (*Cheilo-Lejeunea*) *phyllobola*.† Unfortunately the plant which he studied was not *Lejeunea phyllobola* Nees & Mont. but an undescribed species, afterwards distributed under a manuscript name in Hepaticae Spruceanae. There seems to be in fact no authentic record of *C. phyllobola* from South America. Specimens from Brazil are quoted in the Synopsis, but these, according to Stephani,‡ are referable to *L. oxyloba* Lindenb. & Gottsche.

11. CHEILOLEJEUNEA VERSIFOLIA (Gottsche) Schiffn.

Lejeunea versifolia Gottsche; Wright, Hep. Cubenses (without description); Schiffner, Engler's Bot. Jahrb. **23**: 597. 1897 (as synonym).

Cheilolejeunea versifolia Schiffn. *l. c. pl. 5. f. 1–7.*

Pale olive-green, growing in depressed tufts, often in company with *C. phyllobola:* stems prostrate, 0.04 mm. in diameter, intricately mixed together, copiously bipinnately branched, some of the branches spreading from substratum, flagelliform, leafless except for two or three rudimentary leaves near apex, but with densely

* Engler's Bot. Jahrb. **23**: 591. 1897.

† Hep. Amaz. et And. 259. 1884.

‡ Hedwigia, **29**: 81. 1890.

imbricated underleaves: rhizoids rather abundant: leaves imbricated, very fragile, distinctly smaller toward the base of the branches, the lobe subplane, widely spreading, obliquely ovate, 0.45 mm. long, 0.3 mm. wide, rounded at the apex, margin entire or subrepand, antical margin arching across but scarcely beyond axis, rounded at base, postical margin straight or nearly so, forming an obtuse angle with keel; lobule inflated, ovoid-cylindrical, 0.11 mm. long, 0.04 mm. wide, slightly constricted near apex, keel slightly arched, free margin involute to or beyond apex then truncate to end of keel, apex tipped with a long, unicellular outwardly curved tooth; cells of lobe with uniformly thickened walls, averaging 10 μ in diameter, basal ocelli 40 × 20 μ, consisting of two to six empty inflated cells: underleaves on ordinary axes contiguous or subremote, on flagelliform branches densely imbricated, plane, rotund-suboblate, often subangulate, 0.16 mm. long, 0.19 mm. wide, scarcely decurrent at the base, bifid almost to the middle with acute sinus and acute subconnivent lobes: inflorescence dioicous: ♀ inflorescence sometimes with a simple innovation; bracts unequally bifid, the lobe obliquely ovate, rounded at apex, entire, 0.47 mm. long, 0.42 mm. wide, lobule rhomboid-lingulate, apex obtuse or more rarely apiculate, 0.3 mm. long, 0.15 mm. wide; bracteole plane, broadly ovate, 0.42 mm. long, 0.35 mm. wide, slightly connate on one side with bract, shortly emarginate, bifid at the apex with rounded divisions and acute sinus, sometimes simply emarginate: perianth unknown: ♂ spikes occupying short branches or intercalary on leading branches, bracts in few pairs, large, subglobose, equally lobed, surface slightly roughened from projecting cells.

Type-locality, Cuba (Wright).

On trees. Lake Worth, Florida (Underwood).

Schiffner has described and figured this peculiar little species so fully and so accurately that the description given above is mostly compiled from his. The specimens from Florida agree closely with those distributed in Hepaticae Cubenses.

The leafless flagelliform branches with closely imbricated underleaves are not invariably found in *C. versifolia* and yet they form its most striking peculiarity. They resemble in a marked degree the flagelliform branches of *Frullania Bolanderi*,* a Pacific Coast species found in California and northward. They are much more highly specialized than the leafless branches of the related *C. phyllobola*, where the underleaves are no closer than on ordinary

* Evans, Trans. Conn. Acad. 10: *pl. 2. f. 4.* 1897.

branches. *C. versifolia* also differs from *C. phyllobola* in its smaller size, in its much smaller leaf-cells which scarcely vary in size throughout the lobe, in its basal ocelli, in its more sharply pointed lobules and in its relatively larger underleaves.

Another West Indian species closely related to *C. versifolia* is *C. emarginuliflora* Schiffn.,* a Cuban plant likewise collected and distributed by Wright. According to its author this species has a more graceful habit than *C. versifolia*, its branches are less numerous and are never flagelliform, its leaves are more distant and their lobules are less conspicuously toothed at the apex, its basal ocelli are either wanting or very inconspicuous, its underleaves are smaller, more distant and with a broader sinus, and its female plants are repeatedly floriferous. The fragmentary material distributed in Hepaticae Cubenses shows that these slight differences certainly exist, but it would require the examination of many more specimens before it could be decided whether they were constant enough to be considered specific. In fact Schiffner himself throws doubt on the validity of the species.

12. **Cheilolejeunea pililoba** (Spruce)

Lejeunea (*Eulejeunea*) *pililoba* Spruce, Jour. Linn. Soc. Bot. **30**: 346. *pl. 23. f. 6–8.* 1894.

Pale to dark green, caespitose: stems prostrate, 0.07 mm. in diameter, irregularly branched: rhizoids few: leaves contiguous to imbricated, the lobe obliquely spreading, plane, broadly ovate to orbicular, 0.4 mm. long, 0.35 mm. wide, rounded to very obtuse at apex, margin crenulate from projecting cells or subentire, antical margin arching across or just beyond axis, rounded or sometimes abruptly contracted at base; lobule filiform from a minute, triangular base, 0.17 mm. long, 0.01 mm. wide, consisting of two to twelve cells in a single row, rarely two or three cells wide at or near base; cells of lobe slightly convex, thin-walled, trigones minute, often scarcely evident, intermediate thickenings wanting, cells averaging 14 μ at edge of lobe, 21 μ in the middle and at base: underleaves distant or contiguous, ovate or narrowly ovate, 0.25 mm. long, 0.13 mm. wide, narrowed toward base, bifid to or beyond the middle with erect, lanceolate, acuminate lobes and obtuse to lunulate sinus, margin as in leaves: inflorescence autoicous: ♀ inflorescence borne on a short branch or on a leading branch,

* Engler's Bot. Jahrb. 23: 585. 1897.

innovating on one side, the innovation simple and sterile; bracts complicate, unequally bifid, the lobe widely spreading, ovate to obovate, rounded at apex, 0.55 mm. long, 0.3 mm. wide, lobule with a narrowly rhomboidal base connate with lobe, running out into a subulate, acuminate point ending in a row of three or more cells, 0.25 mm. long, base 0.05 mm. wide; bracteole oblong to obovate from a narrow base, 0.35 mm. long, 0.17 mm. wide, bifid one third or less with triangular, acute, contiguous lobes and narrow sinus, perianth about half exserted, obovoid, somewhat compressed, 0.5 mm. long, 0.35 mm. wide, narrowed toward base, broad and truncate above and with a very short, broad beak, antical face plane or with a very indistinct, low keel near apex, postical keel about half as long as perianth, broad, obtusely two-angled, lateral keels blunt, keels more or less roughened from projecting cells: ♂ spike occupying a short branch, globose, bracts in about two pairs, inflated, keel strongly arched, shortly and subequally bifid with rounded divisions; bracteole at base of spike small, shortly bifid with acute divisions and narrow sinus.

Type-locality, Dominica (Elliott).

On bark or on the ground. Indian River and Cedar Keys, Florida (Herb. Austin). Also known from Cuba (Underwood).

C. pililoba presents so remarkable a character in its filiform lobule that there is little danger of confusing it with any of our other Lejeuneae. Among tropical species *Lejeunea* (*Eu-Lejeunea*) *setiloba* Spruce * is said to have a similar but shorter lobule. Through the kindness of M. B. Slater, the writer has had the privilege of examining the type-material of this species from the Spruce herbarium. These specimens show that the filiform condition of the lobule is by no means a constant feature. On some of the stems one occasionally finds a small, broadly ovate, inflated lobule of the ordinary type with the apex consisting of one or two projecting cells, and there are all gradations between such a lobule and the form described by Spruce. These specimens in fact give one the impression that the filiform lobule of *L. setiloba* is really an abnormal character. Aside from these differences in the lobule, the underleaves of *L. setiloba* are broader and usually less deeply cleft than in *C. pililoba* and are occasionally angular-unidentate on the sides. The perianth also is obovoid and scarcely compressed, and its sharp antical keel indicates that the species is a true *Lejeunea*.

* Hep. Amaz. et And. 281. 1884.

According to Spruce *C. pililoba* should also be placed in his subgenus *Eulejeunea*, but it seems best to transfer it to *Cheilolejeunea* on account of its compressed perianth with obsolete antical keel.

According to the original description, the type-specimens of *C. pililoba* were entirely sterile, and yet on this negative evidence the species was said to be dioicous. The specimens in the British Museum, from which the published figures were drawn, show, however, flowers of both sexes on the same stem. None of the archegonia are fertilized, and the plants look as if they had grown in an unfavorable locality, where they were unable to develop normally. The specimens are not quite so large as those described by Spruce, and the filiform lobule is usually less than twelve cells long, although this length is given as one of the specific characters. The specimens from Florida and also those from Cuba (Matanzas, mixed with Hep. Amer. 145) agree closely with the British Museum specimens. Both are distinctly autoicous and the Cuban plants show well-developed perianths.

13. LEJEUNEA PATENS Lindb.

Jungermannia serpyllifolia Dicks. Fasc. Pl. Crypt. Brit. **4**: 19. 1801.

Pandulphinius serpyllifolius S. F. Gray, Nat. Arr. Brit. Plants, **1**: 689. 1821.

Lejeunea patens Lindb. Acta Soc. Sci. Fenn. **10**: 482. 1875.

Pale or sometimes darker green, slightly glossy when dry, caespitose: stems prostrate or slightly ascending, 0.08 mm. in diameter, copiously and irregularly branched: rhizoids few: leaves imbricated, the lobe ovate, widely spreading, falcate, strongly convex, 0.5 mm. long, 0.35 mm. wide, rounded and decurved at apex, margin distinctly crenulate from projecting cells, antical margin rounded or sometimes contracted at base, arching across or a little beyond axis, postical margin forming an angle of 90° or less with keel, angle in poorly developed leaves often obtuse; lobule strongly inflated, ovate, 0.17 mm. long, 0.1 mm. wide, keel arched, mostly crenulate, free margin curved and involute to beyond apex, then lunately truncate to end of keel, apex tipped with a single blunt, projecting cell; cells of lobe convex, thin-walled, but usually with conspicuous trigones and intermediate thickenings, walls sometimes thin throughout, cells averaging at edge of lobe 14 μ in diameter, in the middle 19 μ, at the base

28 × 23 μ: underleaves distant, about the size of the lobules or a little smaller, orbicular, 0.15 mm. long, strongly convex postically, gradually narrowed toward base, bifid about one half with obtuse to acute lobes separated by a sinus varying from narrow and acute to broader and obtuse, margin crenulate from projecting cells: inflorescence autoicous: ♀ inflorescence sometimes on a leading branch, sometimes on a short branch, innovating on one side, the innovation often but not always floriferous and branched; bracts complicate, unequally bifid, the lobe somewhat spreading, oblong, rounded at the apex, 0.5 mm. long, 0.3 mm. wide, margin crenulate, lobule narrowly oblong, rounded to obtuse at apex, 0.25 mm. long, 0.12 mm. wide; bracteole free or nearly so, ovate-oblong, 0.4 mm. long, 0.25 mm. wide, bifid about one fourth with acute lobes and sinus, margin crenulate; perianth about half exserted, oblong-obovoid, 0.9 mm. long, 0.5 mm. wide, gradually narrowed toward base, rounded above and with a short beak, terete below, sharply five-keeled in upper half or third, the keels crenulate from projecting cells, becoming blunter with age: ♂ spike occupying a short branch, bracts in two to four pairs, strongly inflated and with strongly arched keel, subequally bifid about one fifth with rounded lobes, cells plane; bracteoles limited to base of spike, similar to the underleaves, but smaller: antheridia in pairs.

Type-locality, Ireland (Lindberg).

On rocks. Newfoundland (Waghorne); Nova Scotia (Macoun). The species is also known from Great Britain and from Norway.

Lejeunea patens and the two species which follow are so nearly allied to one another that they have given rise to much confusion. The elucidation of their synonymy is due largely to Lindberg, who was the first to distinguish clearly between *L. serpyllifolia* Lib. and *L. patens*. Although he described the latter as a distinct species, he threw doubts on its validity, recognizing the close relationship which exists between the two species. At the time *L. patens* was published, it was taken for granted that *L. serpyllifolia* Lib. was the same as *Jungermannia serpyllifolia* Dicks.; but in 1879 Lindberg * discovered that the type-specimen of Dickson's species was identical with his *Lejeunea patens*. The name "*Lejeunea serpyllifolia*," however, cannot now be taken up for *L. patens*, on account of the older *L. serpyllifolia* of Libert. At the same time

* Musc. Scand. 2, footnote. 1879.

we can avoid any confusion which might arise from the use of Libert's name by restoring to Libert's species the still older name "*cavifolia*," of Ehrhart, a course which Lindberg and others have already adopted.

L. patens has not before been recorded for America. Its discovery in Newfoundland and in the neighboring island of Cape Breton shows quite conclusively that its range is northern, and that it does not belong to that group of subtropical hepaticae which are characteristic of the southwestern corner of Ireland.

The species has been illustrated by Moore * and also by Pearson.† Moore's figures bring out clearly the crenulations on the leaves and underleaves, an important character which Pearson's figures do not show.

14. LEJEUNEA CAVIFOLIA (Ehrh.) Lindb.

Jungermannia cavifolia Ehrh. Beitr. **4**: 45. 1789.

Jungermannia clavaeflora Nees; Martius, Fl. Crypt. Erl. 137. *pl. 3. f. 10.* 1817.

Lejeunea serpyllifolia Lib. Ann. Gén. Sc. Phys. **6**: 374. *pl. 97. f. 2.* 1820. G. L. & N. Syn. Hep. 374. 1845.

Lejeunea cavifolia Lindb. Acta Soc. Sci. Fenn. **10**: 43. 1871. Not Stephani.‡

Lejeunea serpyllifolia, var. *β cavifolia* Lindb. *l. c.* **10**: 485. 1875.

Lejeunea serpyllifolia, var. *γ Americana* Lindb. *p. p., l. c.* **10**: 486. 1875.

Lejeunea (*Eu-Lejeunea*) *serpyllifolia* Spruce, Hep. Amaz. et And. 262. 1884.

Eulejeunea serpyllifolia Schiffn.; Engler & Prantl, Nat. Pflanzenfam. I^3: 122. 1893.

Pale to dark green, dull or glossy when dry, growing in depressed tufts or creeping over other bryophytes: stems prostrate, 0.07 mm. in diameter, irregularly branched, the branches widely spreading, sometimes few but usually abundant: rhizoids scanty: leaves imbricated, the lobes ovate, obliquely preading, plane to convex, 0.6 mm. long, 0.35 mm. wide, rounded to very obtuse at the apex, margin en-

* Proc. Roy. Irish Acad. II. **2**: *pl. 43.* 1877.

† Hep. Brit. Isles, *pl. 11.* 1890.

‡ Bol. da Soc. Brot. **4**: 171. *pl. 1. f. 5–7.* 1886.

tire or nearly so, antical margin arching across or just beyond axis, slightly rounded at base, postical margin usually forming an angle of 120° or more with keel, angle rarely as small as 90°; lobule strongly inflated, ovate, 0.2 mm. long, 0.14 mm. wide, keel strongly arched, scarcely or not at all crenulate, free margin more or less curved and involute as far as apex, then passing by a shallow lunulate sinus to end of keel, apex tipped with a single, blunt, projecting cell; cells of lobe almost plane, thin-walled, trigones and scattered intermediate thickenings sometimes distinct, sometimes scarcely evident, cells at edge of leaf averaging 17 μ in diameter, in the middle 24 μ, at the base 30 × 21 μ: underleaves distant, as large as or a little larger than lobule, ovate-orbicular, 0.2 mm. long, 0.18 mm. wide, plane or slightly convex postically, gradually narrowed toward base and neither decurrent nor rounded, bifid about one half with rounded to acute lobes and obtuse to acute sinus, margin entire or nearly so: inflorescence autoicous: ♀ inflorescence sometimes on a leading branch, sometimes on a short branch, innovating usually on only one side, the innovation sometimes simple and sterile, sometimes floriferous; bracts complicate, unequally bifid, the lobe somewhat spreading, narrowly to broadly ovate, rounded to obtuse at the apex, entire, 0.5 mm. long, 0.3 mm wide, lobule oblong to lanceolate, rounded to acuminate at the apex, entire, 0.3 mm. long, 0.1 mm wide; bracteole free, oval-obovate, 0.4 mm. long, 0.2 mm. wide, bifid one fourth to one third with acute to obtuse lobes and sinus, margin entire; perianth about half exserted, oblong to oval-oblong from a narrowed base, 0.85 mm. long, 0.4 mm. wide, rounded or truncate at the apex with a short, slender beak, terete below, sharply five-keeled in upper part, the keels smooth, becoming blunter with age: ♂ spike as in *L. patens*.

Type-locality, near Upsala, Sweden (Ehrhart).

On rocks and trees. Ontario (Macoun); New Hampshire (Faxon, Evans); Massachusetts (Stone); Connecticut (Eaton, Hall, Evans); New York (Underwood, Cook, Mrs. Britton); Pennsylvania (Barbour); Wisconsin (Cheney); Minnesota (Holzinger). Widely distributed in Europe and recently reported from Japan.

Exsic.: Hep. Bor.-Amer. 97 *p. p.* Hep. Amer. 8 (as *Lejeunea serpyllifolia*).

Lejeunea cavifolia is the commonest representative of the Lejeuneae in the northern United States. When well developed, it can readily be distinguished from *L. patens* and from *L. Americana*. Poorly or abnormally developed specimens, however, of these closely allied species do not always show their specific characters and cannot always be determined.

Lejeunea patens is a paler plant than *L. cavifolia;* the lobes of its leaves spread more abruptly from the lobules and are more convex, especially when dry; the underleaves are more nearly orbicular and are smaller than the lobules, while the margins of both leaves and underleaves are distinctly crenulate from projecting cells. The leaf-cells also, as a rule, are more strongly convex and show more conspicuous trigones and intermediate thickenings. Unfortunately the abrupt spreading of the lobe from the lobule is not always evident in *L. patens*, especially on the leaves of the smaller branches. Neither is this character by itself to be wholly relied upon in separating the species, for in *L. cavifolia* the lobe sometimes spreads widely also. The figures recently published by Pearson * show how variable both species are in this respect. It is only when the spreading lobe is found in connection with the other peculiarities of *L. patens* that it becomes of value as a differential character.

Lindberg's variety *planiuscula* of *L. cavifolia*, first distinguished simply as a form, hardly seems worthy of varietal rank.† According to the description, the plants of this variety are more elongated, less branched and broader than in the type, the leaves are less imbricated and less decurved, the lobules are relatively smaller and the cells have thinner walls and scarcely evident trigones. Faxon's specimens from Crawford Notch, New Hempshire, and Underwood's from Manlius, New York, agree with this description and also with the specimens which Lindberg quotes, but they are connected with typical *L. cavifolia* by intermediate conditions. Apparently their peculiarities are due to a moister habitat, which would naturally produce a laxer growth and lead to a diminution in the development of the lobules and of the cell-walls.

Two specimens of *Lejeunea* distributed in Hepaticae Americanae should perhaps be noted here. One of them is the curious submerged "*Kantia aquatica*" Underw., distributed as no. 107. As Underwood ‡ himself has shown, this plant is a true *Lejeunea*, apparently related to *L. cavifolia*. As a result of its submerged

* Hep. Brit. Isles, *pl. 10, 11.* 1899.

† *Lejeunea serpyllifolia*, forma *α planiuscula* Lindb. Acta Soc. Sci. Fenn. 10: 484. 1875. *Lejeunea cavifolia*, var. *β planiuscula* Lindb. Musc. Scand. 2. 1879.

‡ Bull. Torrey Club, 23: 383. 1896 (footnote).

habit it has lost its lobules, and, as the specimens have failed to develop perianths, it is impossible to refer them definitely. The other specimen was distributed under no. 178, as *Lejeunea* (*Eu-Lej.*) *serpyllifolia*. The plants seem to be perfectly sterile, the lobes are crenulate on the margins and both lobules and underleaves are very small, the latter being bifid beyond the middle with broad, obtuse lobes and sinus. Evidently the plant is not *L. cavifolia*, but it is in too poor a condition to be determined. Both of these specimens were collected in Florida.

15. **Lejeunea Americana** (Lindb.)

PLATE 20, FIGS. 14–26

Jungermannia serpyllifolia Wils. & Hook. *p. p.*; Drummond, Musc. Amer. St. Merid. 172. 1841. Not Dickson.

Lejeunea serpyllifolia Sull. Musc. Alleg. 272. 1845. Not Libert.

Lejeunea cavifolia Aust. *p. p.* Hep. Bor.-Amer. 97. 1873. Not Lindb.

Lejeunea serpyllifolia, var. γ *Americana* Lindb. *p. p.* Acta. Soc. Sci. Fenn. **10**: 486. 1875.

Lejeunea (*Eu-Lejeunea*) *flava*, subsp. *albida* Spruce, Hep. Amaz. et And. 269. 1884.

Pale, whitish-green or yellowish, closely appressed to substratum or growing in wide, depressed mats: stems prostrate, 0.08 mm. in diameter, irregularly pinnately branched: rhizoids often abundant: leaves imbricated, the lobe ovate, widely spreading, plane or slightly convex, 0.5 mm. long, 0.35 mm. wide, rounded to obtuse at apex, margin entire or subcrenulate from projecting cells, antical margin arching across or just beyond axis, slightly rounded at base, postical margin forming an obtuse angle with keel; lobule inflated, ovate, 0.2 mm. long, 0.15 mm. wide, keel strongly arched, scarcely or not at all crenulate, free margin slightly curved, more or less involute, apex tipped with a single projecting cell, sinus between apex and end of keel shallow and oblique; cells of lobe plane or nearly so, thin-walled, but usually with distinct trigones and occasional intermediate thickenings, averaging 15 μ in diameter at edge of leaf, 23 μ in the middle and 29 × 23 μ at the base: underleaves contiguous or subimbricated, a little larger than lobule, orbicular, 0.2 mm. long, plane or nearly so, rounded or subcordate at base, bifid about one half, segments

usually acute or apiculate, occasionally obtuse, rarely rounded, sinus acute to obtuse, margin entire or irregularly sinuate, rarely with an indistinct, blunt tooth at about the middle of one or both sides: inflorescence autoicous: ♀ inflorescence sometimes on a leading branch, sometimes on a short branch, innovating on one or rarely on both sides, the innovations often floriferous, bracts complicate, unequally bifid, the lobe obliquely spreading, varying from oblong to obovate, rounded to subacute at the apex, 0.6 mm. long, 0.3 mm. wide, lobule mostly oblong and rounded or truncate at the apex, rarely indistinctly toothed or lobed with rounded divisions, 0.35 mm. long, 0.18 mm. wide; bracteole free, ovate, 0.55 mm. long, 0.35 mm. wide, somewhat narrowed at base, bifid about one half with erect, obtuse to acute divisions and narrow sinus; perianth obovoid, often distinctly dilated above middle, 0.7 mm. long, 0.35 mm. wide, gradually narrowed toward base, broad and truncate above, and with a short beak, terete below, sharply five-keeled in upper part, the keels smooth sometimes showing vague traces of wings: ♂ inflorescence usually occupying a short branch, rarely borne on a longer branch, bracts in two to eight pairs, similar to those of *L. patens*: spores greenish, angular, thick-walled, minutely verruculose, averaging 14 μ in short diameter.

Type-locality, Southern States (Austin)?

On trees. North Carolina (Johnson); South Carolina (Sullivant, Miss DuBois); Georgia (Small); Florida (Farlow, J. D. Smith, Underwood, Straub); Alabama (Underwood); Mississippi (Langlois, Lloyd and Tracy); Louisiana (Drummond, Langlois); Texas (Hall). Also known from various parts of tropical America.

EXSIC.: Musc. Amer. St. Merid. 171 *p. p.* (as *Jungermannia serpyllifolia*). Musc. Alleg. 272 (as *Lejeunea serpyllifolia*). Hep. Bor.-Amer. 97 *p. p.* (as *Lejeunea cavifolia*). Hep. Amer. 98 (as *Lejeunea* (*Micro-Lej.*) *Austini*). Hep. Amer. 137 (as *Lejeunea* (*Micro-Lej.*) *lucens*).

In proposing the present species as a variety of *Lejeunea serpyllifolia* Lib., Lindberg referred to it all the American specimens in his herbarium which presumably belonged to that species. His dictum has been followed, almost without exception, by subsequent writers on American hepaticae, who have apparently taken it for granted that typical *L. serpyllifolia* Lib. did not occur in America. Judging, however, from the specimens which Lindberg quotes, his variety was an aggregate, made up of *L. Americana*, as

described above, and *L. cavifolia*. He quotes three exsiccatae, Hep. Bor.-Amer. 97, Musc. Amer. St. Merid. 171 *p. p.* (caespites pallidi) and Musc. Alleg. 272; he also quotes two plants not distributed in exsiccatae, Cleve's specimens from Catskill, New York, and Macoun's from Belleville, Canada. Of the first-mentioned specimen, Austin gives as a habitat, "on rocks and roots of trees; chiefly on mountains." He does not tell, therefore, in what part of the country they were collected. The writer has examined this number in two sets of Hep. Bor.-Amer., and finds in both cases pale tufts, which are clearly *L. Americana*, and darker tufts, which agree perfectly with the European specimens of *L. cavifolia* quoted by Lindberg, as, for example, Hep. Eur. 435. Sullivant's specimens from Charleston, South Carolina, are a poorly developed form of *L. Americana*. They show characteristic perianths, but their leaves and underleaves indicate that they grew in a moist locality, and their thin-walled leaf-cells, with small and often scarcely evident trigones, point to the same conclusion. Drummond's Louisiana specimens are also a poorly developed *L. Americana*. Cleve's specimens have not been examined by the writer, but specimens in the Underwood herbarium from Belleville, collected by Macoun, are typical *L. cavifolia*. It is a little difficult to say what should be considered the type of Lindberg's variety, and consequently of the present species. The writer would suggest, however, that the pale tufts in Hep. Bor.-Amer. 72 be so regarded. Austin's plants are the first ones quoted by Lindberg, and these pale specimens, except for certain characters drawn from the leaf-cells, agree closely with the original description.

Few of our species have been the cause of quite so much confusion as *L. Americana*. It has been referred to *L. cavifolia*, to *Euosmolejeunea durinscula* and also to *Microlejeunea lucens* and is to be found under one or more of these various names (or their equivalents) in most of our large herbaria.

The characters which separate it from *L. cavifolia*, although slight, are sufficiently distinct when well developed specimens are examined. *L. Americana* is a paler plant than the northern species, the lobes of its leaves spread more widely from the axis, the lobules are relatively smaller, and the underleaves are broader, more or less sinuous on their margin and tending to be rounded or subcordate

at the base. The perianth, however, offers the best points of difference; in the new species this is much broader in the upper part than at the base and frequently flares out abruptly above the middle, its keels also are sharper than in *L. cavifolia* and sometimes shows rudimentary wings. In the United States *L. Americana* seems to be confined to the bark of trees, while *L. cavifolia* is more at home on rocks, at the roots of trees, and creeping over other hepatics.

L. Americana is a much paler and more delicate plant than *Euosmolejeunea duriuscula*. Its leaves spread more widely from the axis, and its lobules are relatively larger with their free margins more involute, so that the apical teeth cannot usually be seen without dissection; its underleaves also are larger and not cuneate at the base. In *L. Americana*, moreover, on account of its autoicous inflorescence, perianths are frequently developed, whereas in the other species they are extremely rare.

L. Americana should hardly be confused with *Microlejeunea lucens*. It is in the first place a much larger plant and has an autoicous inflorescence. It differs markedly also in the more conspicuous thickenings of its cell-walls and in its larger and broader underleaves, which are never sharply unidentate on their lateral margins.

Spruce's *L. flava*, subsp. *albida* should apparently be referred to the present species, although his specimens are a little larger and were found on living leaves instead of on bark. Spruce afterwards recognized that the plant was specifically distinct from *L. flava* and distributed it in Hep. Spruceanae as a manuscript species. The writer has carefully compared these specimens with typical plants of *L. Americana* and finds no essential differences between them.

16. **Microlejeunea lucens** (Tayl.)

PLATE 21, FIGS. 1–10

Lejeunea cucullata Sull. Musc. Alleg. No. 274. 1845. Not Nees.

Lejeunea lucens Tayl. Lond. Jour. Bot. **5**: 399. 1846. G. L. & N. Syn. Hep. 764. 1847.

Lejeunea (*Micro-Lejeunea*) *lucens* Spruce, Hep. Amaz. et And. 288. 1884.

Lejeunea (*Eu-Lejeunea*) *lucens* Steph. Hedwigia, **29**: 84. 1890.

Pale green, scattered or growing in depressed tufts: stems prostrate, 0.05 mm. in diameter, sparingly and irregularly branched, the branches sometimes microphyllous: rhizoids scanty: leaves distant to imbricated, the lobe obliquely spreading, ovate, on well-developed axes 0.25 mm. long, 0.17 mm. wide, plane, rounded at the apex or sometimes varying to obtuse, margin entire or subcrenulate from projecting cells, antical margin arching partially across axis, slightly rounded or almost straight at base, postical margin forming a continuous line or a very obtuse angle with keel; lobule on well-developed axes about half as long as lobe, on microphyllous branches sometimes as long as lobe, strongly inflated, ovoid, 0.01 mm. long, 0.09 mm. wide, keel strongly arched, free margin involute to apex, then passing by an obliquely truncate or lunulate sinus to end of keel, apex tipped with a single slightly projecting, almost straight cell; lobule often poorly developed; cells of lobe thin-walled throughout or sometimes with minute trigones and scattered intermediate thickenings, averaging 14 μ in diameter at edge of lobe, 20 μ in the middle and at the base: underleaves distant, ovate, 0.14 mm. long, 0.1 mm. wide, plane, narrowed toward base and not decurrent, bifid to about the middle, with subulate, acute or acuminate divisions ending in a single cell or in a row of two cells and separated by a narrow, obtuse sinus, lateral margins variable, sometimes rounded, sometimes angular, sometimes unidentate, especially on slender branches, the tooth consisting of a single projecting, rounded to acute cell, margin otherwise entire or nearly so: inflorescence dioicous: ♀ inflorescence on a short branch, innovating on one or on both sides, the innovations short and simple, inflorescence very rarely without innovation; bracts complicate, subequally or somewhat unequally bifid, the lobe suberect, oblong-obovate, rounded or very obtuse at the apex, margin entire or subcrenulate, 0.4 mm. long, 0.2 mm. wide, lobule rounded to acuminate at the apex, 0.4 mm. long, 0.2 mm. wide, sometimes narrower; bracteole free or nearly so, ovate, 0.45 mm. long, 0.25 mm. wide, bifid about one third with acute lobes and obtuse sinus, margin subentire, sometimes bearing a blunt lobe-like tooth on one side near the base; perianth scarcely exserted, broadly pyriform, 0.5 mm. long, 0.3 mm. wide, slightly compressed, five-keeled, the keels smooth, beak short: ♂ spike julaceous, occupying the base of an elongated branch; bracts in five or six pairs, as large as the leaves, turgid, the lobule half as large as lobe.

Type-locality uncertain.

On trees or moist rocks: Virginia (Sullivant); Florida (Miss Biddlecome, J. D. Smith, Underwood); Mississippi (Lloyd and

Tracy), Louisiana (Langlois). Widely distributed in tropical America.*

EXSIC.: Musc. Alleg. 274 (as *Lejeunea cucullata*). Hep. Bor.-Amer. 98 (as *Lejeunea cucullata*).

There has been a great deal of confusion about this little species and many specimens have been referred to it which really belong elsewhere. The writer ventures, therefore, to relate its history in some detail.

The specimens in the Taylor herbarium, which are presumably the type, consist of a few fragmentary stems. In the small envelope which contains them there is written in Wilson's handwriting: "*Jung. cucullata* Nees? Ohio, Sullivant, 147. I have very little of it and all barren. W." On the sheet upon which this envelope is pasted Taylor has written: "*Jungermannia lucens* Tayl. Mss. No. 147. Sullivant, Ohio. *Jung. cucullata* Nees? No. 25 Jan.? 1846. W. Wilson." The specimens are not only fragmentary and sterile but on most of the leaves show poorly developed lobules, indicating that they grew in an unfavorable locality. From the notes it would appear that these specimens were collected somewhere in Ohio, and Taylor, in his original description of *Lejeunea lucens*, states that the species came from the vicinity of Cincinnati. The evidence, however, is against this view, as the following facts will show. The more abundant specimens distributed by Sullivant in Musc. Alleg. agree perfectly with those in the Taylor herbarium, and the same may be said of Austin's specimens in Hep. Bor.-Amer. Sullivant's specimens came from Cheat Mountain, Virginia, and Austin's are labeled, "On moist rocks in the Alleghany Mountains, Sullivant." In the second edition of Gray's Manual, Sullivant limits the range of his "*L. cucullata*" to the Alleghany Mountains and quotes Taylor's *L. lucens* as a synonym. Apparently then no one has collected the species in the northern United States with the exception of Sullivant, and, as all of his specimens came from the Alleghany

* *Lejeunea cucullata* is listed as a Massachusetts plant by Tuckerman and Frost in their "Catalogue of Plants growing without cultivation within thirty miles of Amherst College" (1875, p. 53). Unfortunately the specimens are now inaccessible, so that it is impossible to say whether they represented *Microlejeunea lucens* or merely a small form of *Lejeunea cavifolia*, the latter of course being much more probable.

Mountains, those in the Taylor herbarium could not have come from Ohio.

All of these specimens from the Alleghany Mountains are perfectly sterile and many different conclusions have been drawn from them. As we have already seen they were referred by Sullivant to *L. cucullata* Nees and by Taylor to his *L. lucens*. Spruce thought at first that they were the same as the Mexican *L. diversifolia* Gottsche * and afterwards transferred them to his *L. diversiloba*.† Still later he referred them with some hesitation to *L. lucens*.‡ Carrington suggested that they were probably the same as *L. crenulifolia* Gottsche Ms. from the island of Trinidad.§

If these specimens, which are so doubtful, are to be regarded as the type-specimens, the species is certainly unfortunate. Spruce, however, considered that the type of *Lejeunea lucens* was a specimen which Taylor had deposited in the Kew herbarium.|| This specimen came from Brazil and was labeled: "Pará, in cortice (T. L. R.) in Herb. Hook." In his original description Taylor states that his specimens came from the Hooker herbarium, and this fact would of course support Spruce's view. Spruce was able to identify with this Kew specimen a fertile plant which he himself had collected near Pará and in this way gave the species a firm footing. The specimens from Florida and Louisiana agreeing closely with this South American plant, perhaps it would be wisest to follow Spruce and consider the Pará plant at Kew as the type of *Microlejeunea lucens*. We can then refer tentatively to this species the doubtful Alleghany Mountain specimens, until something more definite is learned about them.

The generic position of the present species is not altogether definite. By Spruce it was first placed in the subgenus *Micro-*

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* Mex. Leverm. 227. 1863. Not *L. diversifolia* Mitt. Spruce (Jour. Bot. 5: 198, footnote. 1876) at first referred to this Mexican species not only Sullivant's Alleghany Mountain specimens but also the minute plant from Ireland which later became the type of his *L. diversiloba*. He decided afterwards that all three were distinct and that the Mexican plant was really the same as his *L. erectifolia* from South America.

† Jour. Bot. 5: 235. 1876.

‡ *L. c.* 25: 37, 39. 1887.

§ Trans. Bot. Soc. Edin. 13: 469. 1879. *Microlejeunea crenulifolia* Steph. Hedwigia, 35: 114. 1896.

|| Hep. Amaz. et And. 288. 1884. Jour. Bot. 25: 37. 1887.

Lejeunea, while Stephani * considered it a *Eu-Lejeunea*. Both of these opinions were afterwards reversed, Spruce † placing it in *Eu-Lejeunea* and Stephani ‡ in *Micro-Lejeunea*. As a matter of fact it is intermediate between the two genera, and it is here placed in *Microlejeunea* because it seems to have more in common with our other species of this genus that it does with our species of *Lejeunea* proper. Its differential characters will be discussed in connection with the remaining species of *Microlejeunea*.

17. **Microlejeunea Ruthii** sp. nov.

PLATE 21, FIGS. 11–19

Pale or dull green, scattered among other hepatics or loosely depressed-caespitose: stems prostrate, 0.04 mm. in diameter, sparingly and irregularly branched, the branches widely spreading: rhizoids scanty: leaves distant to loosely imbricated, the lobe obliquely spreading to suberect, ovate or broadly ovate, 0.35 mm. long, 0.25 mm. wide, rounded at the apex, margin subentire or slightly angular-sinuate, antical margin extending partially across axis, almost straight or slightly rounded at base, often a little contracted just above insertion, postical margin almost straight, forming a continuous line or sometimes on robust axes a very obtuse angle with keel; lobule about half as long as lobe, strongly inflated, ovoid, 0.17 mm. long, 0.13 mm. wide, keel more or less arched, free margin curved, strongly involute to apex, then passing by an oblique and lunulate sinus to end of keel, apex tipped with a single projecting, sometimes outwardly curved cell; cells of lobe plane or slightly convex, walls somewhat thickened with indistinct trigones and occasional intermediate thickenings, averaging 12 μ in diameter at the edge of lobe, 18 μ in the middle and at the base: underleaves distant, orbicular, 0.14 mm. long, narrowed toward base and neither rounded nor decurrent, bifid to about the middle with broad, suberect, triangular lobes and obtuse sinus, lobes subacute or acute, ending in a single cell or in a row of two cells, or robust stems usually four cells long and four cells wide at base, margin entire or subcrenulate from projecting cells, lateral margins rounded, never toothed: inflorescence dioicous: ♀ inflorescence borne on a leading branch, innovating on one side, the innovation usually long and sterile; bracts complicate, deeply and unequally bifid, the lobe obliquely spreading, ovate to oblong, 0.5 mm. long,

* Hedwigia, 29: 84. 1890.

† Jour. Linn. Soc. Bot. 30: 348. 1894.

‡ Bot. Gazette, 17: 171. 1892.

0.25 mm. wide, rounded or very obtuse at the apex, margin as in leaves but usually more sinuate, lobule mostly ligulate, rounded at the apex, varying to subacute, 0.3 mm. long, 0.1 mm. wide, keel wingless or nearly so; bracteole free, ovate from an abruptly contracted base, 0.5 mm. long, 0.35 mm. wide, bifid about one third with sharp, more or less contorted segments and narrow sinus, margin as in bracts: perianth and ♂ inflorescence unknown.

On bark. Big Frog Mountain, Tennessee (A. Ruth), the type-locality.

Microlejeunea Ruthii is closely related to the European *M. ulicina* (Tayl.), agreeing with it in its general habit and dioicous inflorescence. In *M. ulicina*, however, the lobes of the leaves are more convex and tend to be more or less pointed, the leaf-cells have thinner walls, and the underleaves are more deeply divided, the narrower divisions being as a rule only two cells wide at the base. The bracts also are more distinctly winged at the keel, their lobes are more pointed and are often denticulate on the margin, while the bracteole is narrower.

Although firmer in texture than *M. lucens* and darker in color, *M. Ruthii* resembles this species in several respects. It may be distinguished by the less widely spreading lobes of its leaves, by its slightly smaller cells with thicker walls, and by its broader underleaves, which have broader segments and are never unidentate on the sides. The ♀ inflorescence also is borne on a leading branch instead of on a short branch as is usual in *M. lucens*.

18. **Microlejeunea Cardoti** (Steph.)

Lejeunea (*Micro-Lejeunea*) *Cardoti* Steph. Bot. Gazette, **17**: 172. 1892.

Dark green, loosely depressed-caespitose: stems prostrate, 0.03 mm. in diameter, copiously and irregularly branched, the branches widely spreading: rhizoids scanty: leaves distant to loosely imbricated, the lobe obliquely spreading, ovate, 0.25 mm. long, 0.17 mm. wide, plane, apex broad and rounded, margin entire or subcrenulate from projecting cells, antical margin arching across axis and rounded at base, postical margin usually forming a continuous line with keel; lobule inflated, ovoid, 0.14 mm. long, 0.08 mm. wide, keel strongly arched, more or less involute to apex, then passing by a lunulate sinus to end of keel, apex tipped with a single projecting, straight or outwardly curved

cell; lobule often poorly developed; cells of lobe plane or nearly so, thin-walled throughout or with very indistinct trigones, averaging 13 μ in diameter, ocelli at base of lobe usually present in robust leaves, consisting of one to three enlarged cells, 25 μ in diameter: underleaves distant, ovate, 0.07 mm. long, 0.05 mm. wide, narrowed toward base and neither rounded nor decurrent, bifid beyond middle with narrow, lanceolate divisions and acute sinus, the divisions about two cells broad at base and ending in a row of two to four cells: inflorescence dioicous: ♀ inflorescence borne on a leading branch, innovating on one side, the innovation mostly simple and sterile; bracts complicate, somewhat unequally bifid, the lobe obliquely spreading, oblong to obovate, 0.35 mm. long, 0.15 mm. wide, rounded to very obtuse at apex, margin entire, lobule ovate, obtuse to subacute, 0.3 mm. long, 0.1 mm. wide, keel wingless or with a very narrow and indistinct interrupted wing; bracteole free, ovate, 0.25 mm. long, 0.12 mm. wide, bifid about one third with subacute lobes and sinus; perianth somewhat exserted, pyriform from a narrowed base, inflated, 0.5 mm. long, 0.35 mm. wide, rounded at apex and with a short beak, obtusely five-keeled: ♂ spike occupying a short branch, sometimes proliferating and giving off short branches beyond inflorescence; bracts in about two pairs, inflated, subequally bilobed with obtuse divisions: bracteole at base of spike similar to underleaves: spores greenish, with a thickened minutely verruculose wall, averaging 23 μ in short diameter, varying in length.

On bark of willow. Pointe a la Hache, Louisiana (Langlois), the type-locality; also reported from Mexico.

The specimens of *M. Cardoti* at the writer's disposal are so poorly developed that it is impossible to gain from them a clear idea of the species. On this account, no figures are given. The plants from Louisiana, collected by Langlois, are presumably the type specimens, as they are the ones first quoted by Stephani. They are perfectly sterile and all their lobules are apparently rudimentary. They seem to lack also the basal ocelli which are ascribed to the species. In the plants from Mexico (Hep. Amer. 136), a few of the stems bear perianths and some of the lobes show ocelli, but even here a well developed lobule is rare. The original description was probably drawn from the Mexican specimens.

Stephani compares *M. Cardoti* with *M. ulicina*, *M. bullata* and *M. lucens;* it is also related to *M. Ruthii*. It can be distinguished from *M. ulicina* by its relatively smaller lobule, by its slightly smaller leaf-cells, and by the rounded lobes and entire margins of

its perichaetial bracts. The same peculiarities of the bracts will also serve to separate it from *M. bullata*, which is a much smaller plant with more erect lobes and relatively larger lobules. It differs from *M. lucens* in its darker color, in its smaller leaf-cells, and in its smaller and differently shaped underleaves. Its underleaves will also distinguish it from *M. Ruthii*, a larger plant, the leaf-cells of which are also larger and have slightly thickened walls.

19. **Microlejeunea bullata** (Tayl.)

PLATE 21, FIGS. 20–29

Lejeunea bullata Tayl. Lond. Jour. Bot. 5: 398. 1846.

Lejeunea (*Micro-Lejeunea*) *bullata* Spruce, Hep. Amaz. et And. 289. 1846.

Pale or bright green, scattered or loosely depressed-caespitose: stems prostrate, closely appressed to substratum, 0.03 mm. in diameter, sparingly and irregularly branched, the branches widely spreading: rhizoids scanty: leaves distant, the lobe erect or slightly spreading, ovate, 0.17 mm. long, 0.1 mm. wide, rounded to obtuse at the apex, margin entire or subcrenulate from projecting cells, antical margin variable, sometimes arching across axis and rounded at base, sometimes almost straight and reaching just beyond edge, postical margin forming a continuous line with keel; lobule strongly inflated, ovoid, 0.14 mm. long, 0.08 mm. wide, keel strongly arched, free margin entire, plane or usually involute to apex, then obliquely lunulate to end of keel, apex tipped with a single, straight or outwardly curved projecting cell; cells of lobe more or less convex, thin-walled throughout or sometimes with very minute trigones, averaging 12 μ in diameter: underleaves distant, ovate to orbicular, 0.06 mm. long, 0.05 mm. wide, narrowed toward base and not decurrent, bifid to beyond the middle with obtuse to lunulate sinus and subulate, erect or connivent lobes, three to five cells long, two cells wide at base and ending in a row of two cells, margin entire: inflorescence dioicous: ♀ inflorescence on a leading branch with a single, sterile and simple innovation; bracts complicate, subequally bifid, the keel wingless or with a narrow, crenulate wing, lobe obliquely spreading, oblong, 0.36 mm. long, 0.12 mm. wide, rounded to acute at the apex, crenulate on margins, lobule narrower, 0.33 mm. long, 0.08 mm. wide, usually acute, crenulate on margin or sometimes with a blunt tooth near apex; bracteole slightly connate on both sides, oblong, 0.3 mm. long, 0.15 mm. wide, bifid about two fifths, sinus variable, divisions acute to acuminate, margins crenulate, sometimes denticu-

late in upper part; perianth pyriform, 0.4 mm. long, 0.2 mm. wide, rostellate, sharply five-keeled, smooth: ♂ inflorescence occupying a short branch, often proliferating at the end; bracts in two to four pairs, larger than the leaves, imbricated, strongly inflated, subequally bifid with a very shallow sinus, the lobes rounded at the apex and entire; bracteoles similar to underleaves, present only at base of spike.

Type-locality, St. Vincent (Guilding).

On bark: South Carolina (Sullivant); Florida (J. D. Smith, Mrs. Russell, Underwood, Straub). Found also at various places in tropical America.

EXSIC.: Hep. Amer. 132 *p. p.* (as *Lejeunea* (*Colo-Lej.*) *minutissima*).

Microlejeunea bullata is our smallest representative of the Lejeuneae. It has not before been recorded for the United States, but seems to be common in Florida. When growing by itself its minute size makes it almost invisible, but as it often grows in company with other species it has been collected several times. The type-specimens agree closely with those from Florida.

According to Lindberg, *M. ulicina* occurs in Sullivant's Musc. Alleg. 272, mixed with *Lejeunea Americana*. In one example of this exsiccata examined by the writer, there seems to be no admixture whatever; in another example there is a single sterile stem of *M. bullata*, and it is probable that Lindberg confused this species with *M. ulicina*. At all events it seems advisable to omit the latter species from our lists until its presence is more definitely established.

M. ulicina is about twice as large as *M. bullata*, its leaves spread a little more from the axis and tend to be more pointed, the cells of the lobe are considerably larger, averaging 18 μ in diameter, the cell-walls are thicker and usually show minute trigones, while the lobules are relatively smaller. The perichaetial bracts of the two species, except for the difference in size, resemble each other very closely, but the bracteole of *M. ulicina* is entire or nearly so, while that of *M. bullata* is crenulate or denticulate.

M. bullata has also been confused with *Cololejeunea minutissima*, with which it often grows. The presence of underleaves will at once distinguish it from this species, and there is little danger of confusing it with any of our other Lejeuneae.

20. COLOLEJEUNEA MINUTISSIMA (Smith) Schiffn.

Jungermannia minutissima Smith, Eng. Bot. *pl. 1633.* 1806.

Jungermannia inconspicua Raddi, Mem. Mat. e Fis. Soc. Ital. Sci. Mod. **18**: 34. *pl. 5. f. 2.* 1820.

Lejeunea minutissima Dumort, Comm. Bot. 111. 1822. G. L. & N. Syn. Hep. 387. 1845.

Lejeunea minutissima β inconspicua Nees, Naturgesch. Eur. Leberm. **3**: 279. 1838.

Jungermannia parvula Wils. & Hook.; Drummond, Musc. Amer. St. Merid. 172. 1841.

Lejeunea Taylori Spruce, Ann. Nat. Hist. II. **4**: 116 (footnote). 1849.

Lejeunea inconspicua De Not. Mem. Acc. Tor. II. **22**: 386. *pl. 5. f. 27.* 1865.

Lejeunea parvula Aust.; Lindb. Acta Soc. Sci. Fenn. **10**: 481. 1875.

Lejeunea (*Colo-Lejeunea*) *minutissima* Spruce, Hep. Amaz. et And. 293. 1884.

Lejeunea (*Colo-Lejeunea*) *parvula* Steph. Bot. Gazette, **17**: 171. 1892.

Cololejeunea minutissima Schiffn.; Engler & Prantl, Nat. Pflanzenfam. I^3: 122. 1893.

Dark green, varying to yellowish, scattered or loosely depressed-caespitose: stems prostrate, geniculate at nodes, 0.05 mm. in diameter, irregularly branched: rhizoids somewhat abundant: leaves distant to subimbricated, the lobe obliquely to widely spreading, convex, ovate to subrotund, 0.22 mm. long, 0.19 mm. wide, rounded or very obtuse at the apex, margin crenulate from projecting cells, antical margin arching wholly or partially across axis and slightly rounded at the very short base, postical margin forming a continuous line with keel; lobule strongly inflated, ovoid, 0.19 mm. long, 0.12 mm. wide, keel strongly arched, free margin curved, involute about half its length, bearing an obtuse or rounded tooth just beyond middle, then obliquely truncate or lunulate with a tooth composed of two rounded cells midway between the obtuse tooth and end of keel; lobule often imperfectly developed, in such cases sometimes plane or nearly so, with an almost straight keel and one or both of the marginal teeth obsolete; stylus reduced to a single papilla, sometimes borne on the basal marginal cell of the lobule, early obsolete; cells of lobe convex on

both surfaces, thin-walled and without trigones, averaging 18 μ in diameter: inflorescence autoicous: ♀ inflorescence on a leading branch, rarely on a short branch, with one or rarely two innovations; bracts somewhat complicate, unequally or subequally bifid, the sinus sometimes very shallow, lobe obliquely spreading, narrowly oblong, 0.4 mm. long, 0.17 mm. wide, rounded at the apex, lobule similar to lobe but sometimes obtuse at the apex, 0.35 mm. long, 0.12 mm. wide, margin crenulate from projecting cells: perianth obovoid, well exserted, 0.5 mm. long, 0.3 mm. wide, cuneate toward base, truncate or rounded at the apex and with a short broad beak, sharply five-keeled in upper part, surface papillose from convex cells: ♂ spike sometimes on a short branch, sometimes on a longer branch; bracts in two to eight pairs, imbricated, very concave, subequally bilobed, the lobes rounded or very obtuse, crenulate, postical lobe without marginal teeth; antheridia borne singly or in pairs: spores greenish with a thickened, minutely verruculose wall, angular, averaging 17 μ in diameter.

Type-locality, England.

On trees. South Carolina (Ravenel); Florida (J. D. Smith, Mrs. Russell, Underwood, Straub); Alabama (Sullivant); Mississippi (Lloyd and Tracy); Louisiana (Drummond, Langlois); Texas (Wright). Widely distributed in southern and western Europe.

EXSIC.: Musc. Amer. St. Merid. 172 (as *Jungermannia parvula*). Musc. Alleg. 276 (as *Lejeunea minutissima*). Hep. Amer. 132 *p. p.* (as *Lejeunea* (*Colo-Lej.*) *minutissima*).

The complicated synonymy of *Cololejeunea minutissima* is due largely to the fact that for many years it was not clearly distinguished in Europe from *Microlejeunea ulicina*. It is probable indeed that the original *Jungermannia minutissima* was a mixture of these two species, which frequently grow together and bear much superficial resemblance to each other. In this country *C. minutissima* has been similarly confused with *Microlejeunea bullata*. It can of course be readily distinguished from both these species by its autoicous inflorescence, geniculate stems and particularly by the entire absence of underleaves.

The species is variable, and it is not unusual to find specimens in which the lobules are poorly developed. This is even true of fruiting plants, where the stems bearing perianths tend to be crowded together in the middle of a tuft. In such cases the sterile stems around the edges are likely to be more characteristic. Of the published figures of this species, the only one which brings

out clearly the marginal teeth of the lobule is that of Stephani,* illustrating a luxuriant form from Portugal. All the other figures seem to have been drawn from imperfectly developed material.

Although Lindberg recognized *Lejeunea parvula* as a distinct species he failed to give a complete description of it. He stated merely that it agreed with *L. minutissima* in being autoicous and in having no underleaves but that it differed in its spreading, semioval and plane lobules. These slight differences by themselves in so variable an organ as the lobule are hardly sufficient to separate the two species. Lindberg referred to *l. parvula* the specimens distributed by Drummond as *Jungermannia parvula* and those distributed by Sullivant as *L. minutissima*. The writer has examined both and finds that the material is not only fragmentary but badly weather-worn. It is sufficient, however, to indicate that the specimens are the same as that rather common species of the Southern States, which subsequent writers have referred, without question, to *L. minutissima*. There seems to be no reason, therefore, for trying to hold *L. parvula* distinct. It should perhaps be noted that sometimes, in American specimens, the lobe is more narrowed at the apex and less crenulate than in European plants. Both of these very slight differences, however, are inconstant. American specimens in which the lobes are just as blunt and just as crenulate as in normal European forms are also frequent, and intermediate conditions exist between the two extremes.

C. minutissima is our smallest *Cololejeunea*. It can easily be distinguished from our other three species by its relatively larger lobule and extremely rudimentary stylus. From *C. Jooriana*, with which it sometimes grows, it differs also in its autoicous inflorescence, in its total lack of hyaline cells, in the shape and in the distinctly crenulate margin of its leaf-lobes.

21. **Cololejeunea Biddlecomiae** (Aust.)

Lejeunea calcarea Sull. Musc. Alleg. 275. 1845. Not Libert.

Lejeunea echinata Aust. Hep. Bor.-Amer. 99. 1873. Not Taylor.

Lejeunea Biddlecomiae Aust.; Pearson, List of Canadian Hepaticae, 5. *pl. 5*. 1890.

* Hedwigia, 26 : *pl. 1. f. 1.* 1887.

Pale or bright green, scattered or depressed-caespitose: stems prostrate, 0.04 mm. in diameter, irregularly pinnately branched: rhizoids somewhat abundant: leaves distant to imbricated, the lobe obliquely to widely spreading, plane or usually convex, ovate, 0.35 mm. long, 0.2 mm. wide, apex varying from rounded to acute, usually obtuse, margin crenulate or denticulate from projecting cells, antical margin arching just across axis, slightly rounded at the very short base, postical margin almost straight, forming a continuous line with keel: lobule inflated, at least near keel, ovoid to globose, 0.17 mm. long, 0.15 mm. wide, keel strongly arched, free margin curved, involute about half its length, bearing an obtuse or rounded, sometimes indistinct tooth just beyond the middle, then obliquely truncate to end of keel, with a tooth usually composed of two rounded cells midway between the blunt tooth and the end of keel; stylus mostly conspicuous, usually composed of two to ten cells in a single row, sometimes two cells broad a part of its length, in rare cases reduced to a single papilla; cells of lobe thin-walled, usually with minute trigones, averaging 10 μ in diameter at edge of lobe, 13 μ in the middle and 21 × 13 μ at base, walls on outer surface of lobe convex to conical, sometimes with a distinct thickening or wart in the middle; cells of lobule plane: inflorescence dioicous or autoicous: ♀ inflorescence borne on a leading branch, innovating on one side; bracts unequally bifid, the lobe obliquely spreading, broadly ovate, 0.35 mm. long, 0.2 mm. wide, obtuse to acute at the apex, lobule orbicular, 0.17 mm. long, margin denticulate and outer surfaces of both lobe and lobule papillose from projecting cells; perianth partly exserted, obovoid to oblong, 0.6 mm. long, 0.35 mm. wide, not compressed, rounded to truncate at the apex, with a short beak, sharply five-keeled in upper part, surface roughened from projecting cells except near the base: ♂ spikes usually borne on leading branches; bracts in two to five pairs, imbricated, similar to the leaves, but with a proportionately larger lobule; antheridia borne singly or in pairs.

Type-locality, Canada (Macoun).

On trees or rocks: Ontario (Macoun, Dearness); Massachusetts (Stone); Connecticut (Eaton, Underwood, Evans); New York (Underwood); New Jersey (Rau); District of Columbia (Coville, Maxon); Ohio (Miss Biddlecome, Beardslee, Wilcox, Werner); Florida (Miss Biddlecome); Alabama (Sullivant).

EXSIC.: Musc. Alleg. 275 (as *Lejeunea calcarea*). Hep. Bor.-Amer. 99 (as *Lejeunea echinata*). Hep. Amer. 51 (as *Lejeunea* (*Colo-Lej.*) *calcarea*. Can. Hep. 13 (as *Lejeunea calcarea*).

Cololejeunea Biddlecomiae is closely related to the European

C. calcarea (Lib.) Schiffn. In the latter species the lobes of the leaves are narrower than in *C. Biddlecomiae* and much more pointed, varying from acute to acuminate; they spread more widely from the stem and the postical margin is incurved beyond the keel; the lobule is more inflated with its free margin strongly involute, the roughness of the leaves is more pronounced, and the stylus is commonly shorter.

Although Spruce at one time tentatively accepted *C. Biddlecomiae* as a species, he afterwards regarded it as a luxuriant form of *C. calcarea*. This opinion was based on the fact that it is sometimes difficult to distinguish certain specimens of the American species from certain specimens of the European. The forms which resemble each other so closely, however, seem to be always imperfectly or abnormally developed plants in which some of the specific characters fail to show themselves in a satisfactory manner. When robust and well developed specimens are examined, there is little difficulty in distinguishing between them. *C. calcarea* grows preferably on limestone rocks, it seems to be much rarer on siliceous rocks and there are few records of its occurence on trees. *C. Biddlecomiae*, on the contrary, attains its best development on trees, particularly in cedar-swamps, and although it is not infrequent on siliceous rocks, it is often less robust in such localities. Whether it is abundant on calcareous rocks does not appear from the specimens examined. The poorly developed specimens, growing on rocks, are the ones which can scarcely be distinguished from rudimentary plants of *C. calcarea*, as for example the specimens distributed by Gottsche and Rabenborst in Hep. Eur. 323. Since however no *typical* specimens of *C. calcarea* have as yet been collected in America, it seems wisest to refer these doubtful rock-forms to *C. Biddlecomiae*.

The presence or absence of a stylus has been used as a distinguishing mark between species of *Cololejeunea*. This practice is not absolutely correct because the stylus is always present, although sometimes reduced to a unicellular papilla which early shrivels up and disappears. Where the stylus is filiform, the papilla can often be detected somewhere near its apex. Regarding the morphological value of the stylus, opinions have varied. Nees von Esenbeck and afterwards Spruce looked upon it as one of the

divisions of a bifid underleaf, the other having become obsolete. Stephani calls attention to the improbability of this view. As a matter of fact the postical segments cut off from the apical cell bear no appendages whatever except the rhizoids. The stylus, on the other hand, arises from a lateral segment which normally bears a leaf, and there seems to be no reason why it should not be considered homologous with the stylus of *Frullania*, which is acknowledged to be a part of the leaf.

In a note sent by Spruce to Underwood, it is stated that a few stems of the European *Cololejeunea Rosettiana* (Massal.) Schiffn. occur mixed with Hep. Amer. 51. Apparently on the strength of this statement, Underwood has listed the species as an American plant. In the two sets of Hep. Amer. examined by the writer, no. 51, which grew on trees, is made up entirely of *C. Biddlecomiae;* and since *C. Rossettiana* has not been collected in Europe except on calcareous rocks, perhaps it would be well to omit it from our lists until its presence is more definitely proved. *C. Rossettiana* was first recoganized in Italy, but has since been detected on the British Isles and in western France. It often grows in company with *C. calcarea*, with which it was long confused. It differs from this species in its broader and even rougher lobe and in its plane lobule, which is denticulate on the margin and rough on the postical surface. Its stylus also is reduced to a unicellular papilla, which is often difficult to demonstrate.

22. **Cololejeunea Macounii** (Spruce)

PLATE 22, FIGS. 1–8

Lejeunea (*Cololejeunea*) *Macounii* Spruce; Underwood, Bull. Torrey Club, **17**: 259. 1890.

Pale green or yellowish, scattered or loosely depressed caespitose: stems prostrate, 0.08 mm. in diameter, irregularly pinnately branched: rhizoids not abundant: leaves imbricated, the lobes suberect to obliquely spreading, straight or slightly falcate, plane, oblong-obovate, on robust plants 0.7 mm. long and 0.45 mm. wide, rounded at the apex, margin entire or subcrenulate from projecting cells, antical margin not arching across axis, almost straight near base, postical margin forming an almost continuous line with keel; lobule inflated at least near keel, ovate in outline, 0.4 mm. long, 0.2 mm. wide, keel arched, free margin usually plane and

appressed to lobe, bearing an acute tooth beyond the middle, then obliquely truncate to end of keel with a tooth composed of two rounded cells midway between the acute tooth and end of keel; stylus inconspicuous and soon obsolete, composed of two or rarely of three cells in a row, sometimes reduced to a one-celled papilla; cells of lobe thin-walled with small but distinct trigones and occasional intermediate thickenings averaging 10 μ in diameter at edge of lobe, 20 μ in the middle and 25 × 20 μ at the base, walls on outer surface of lobe slightly convex, each cell, except those near the base, bearing a single, large, short-cylindrical, rounded projection, representing a local thickening of the wall: inflorescence dioicous: ♀ inflorescence borne on a leading branch innovating on one side; bracts complicate, unequally bifid, the lobe similar to the leaf-lobes but narrower, 0.6 mm. long, 0.3 mm. wide, lobule ovate, 0.35 mm. long, 0.17 mm. wide, apiculate or subacuminate at apex, margin and cells of lobe as in leaves; perianth exserted, obconic in lower part, rectangular-oblong above, 0 75 mm. long, 0.3 mm. wide, slightly compressed, subtruncate at apex, sharply five-keeled, the entire surface except near the base roughened as in leaves: ♂ inflorescence unknown.

On maple bark. British Columbia (Macoun), the type-locality.

EXSIC.: Hep. Amer. 177 (as *Lejeunea* (*Colo-Lej.*) *Macounii*).

Spruce's original description of *C. Macounii*, which was published by Underwood, is so complete that very little has been added to it. In fact the characters of the perianth as stated above are taken wholly from this description, the perianths in the specimens examined by the writer being either too young or too old to show these characters clearly.

In its rough leaves *C. Macounii* resembles *C. Biddlecomiae*, but in the latter species the roughness is due mainly to the very convex or conical cell walls, while in *C. Macounii* it is due almost entirely to the globose warts on the cells. In *C. Macounii* also the lobe is rounded at the apex with its broadest part above the middle, while in *C. Biddlecomiae* the lobe is more or less sharply pointed with its broadest part below the middle. There are also differences in the marginal teeth of the lobule.

In an interesting note to Underwood, Spruce compares *C. Macounii* with two autoicous species of tropical America—*C. cardiocarpa* (Mont.) and *C. platyneura* (Spruce). Both of these species differ in their compressed perianth with a low, bluntly two-angled, postical keel, which is almost obliterated at maturity. *C.*

cardiocarpa differs also in the hyaline apex of its lobe and in its muticous lobule, while *C. platyneura* shows a very small lobule and a false nerve of elongated cells in the lobe.

23. **Cololejeunea Jooriana** (Aust.)

PLATE 22, FIGS. 9–20

Lejeunea Jooriana Aust. Bull. Torrey Club, **6**: 20. 1875.

Lejeunea (*Colo-Lejeunea*) *Jooriana* Steph. Bot. Gazette, **17**: 171. 1892.

Yellowish-green or whitish, darkening somewhat with age, scattered or loosely depressed-caespitose: stems prostrate, 0.05 mm. in diameter, irregularly pinnately branched: rhizoids somewhat abundant: leaves imbricated, the lobe widely spreading, plane, ovate, 0.5 mm. long, 0.35 mm. wide, gradually narrowed from just below the middle to the rounded, obtuse or subacute apex, margin entire or subcrenulate from projecting cells, antical margin arching across axis and rounded at the very narrow base, postical margin forming a continuous line with keel, almost straight from end of keel to apex; lobule inflated, ovoid, 0.25 mm. long, 0.15 mm. wide, keel arched, free margin involute about half its length, bearing an obtuse tooth just beyond the middle, then obliquely truncate or lunulate to end of keel, with a tooth composed of two rounded cells midway between the obtuse tooth and the end of keel: stylus inconspicuous and soon obsolete, composed of two cells in a row or reduced to a one-celled papilla; cells of lobe scarcely convex, with slightly thickened walls, very inconspicuous trigones and occasional, minute intermediate thickenings, averaging 14 μ in diameter at edge of leaf, 18 μ in the middle and 25 × 18 μ at base; hyaline cells at apex one to ten in number, radially elongated, usually in a single row, united at their basal ends but often with rounded, more or less spreading, free extremities, hyaline cells sometimes present also along a part of antical margin, sometimes absent altogether, usually becoming very indistinct with age: inflorescence synoicous and sometimes paroicous: ♀ inflorescence usually borne on a leading branch, more rarely on a short branch, innovating on one side, the innovation sometimes floriferous; bracts similar to the leaves, unequally bifid, with more or less inflated lobule and arched keel, lobe narrowly ovate, 0.5 mm. long, 0.25 mm. wide, margin slightly crenulate from projecting cells, usually with a small group of hyaline cells at apex and occasionally on antical margin, lobule ovate, 0.35 mm. long, 0.2 mm. wide, crenulate or denticulate in upper part from projecting cells and sometimes bearing one to three hyaline cells at apex, stylus sometimes three

or four cells long; perianth about half exserted, broadly ovoid to obovoid, 0.55 mm. long, 0.4 mm. wide, rounded at the base and rounded, truncate or very slightly retuse at apex, with an extremely short and indistinct beak, somewhat flattened, antical face plane or with a broad low keel, lateral keels sharp to blunt, postical keel broad, obtusely two-angled, cells of perianth with thicker walls than the leaf-cells, slightly convex, especially along keels: antheridia borne singly or in pairs in the axils of the ♀ bracts and sometimes in the unmodified leaf below the innovation: spores more or less elongated, angular, greenish, with a thickened, minutely verruculose wall, averaging 14 μ in short diameter.

Type-locality, Louisiana (Joor).

On bark and on reeds. North Carolina (Johnson); Florida (J. D. Smith, Underwood). Also known from Bermuda (Howe).

Austin's original description of this interesting species is incomplete and omits several of its most essential characters. For this reason the species has not been understood, and although specimens of it have been collected several times and at various localities, they have most of them been referred to *C. minutissima*, with which they really have less in common than with either of our other species. Apparently no one except Austin studied the type-material. Underwood's description, the only one since published, is simply a translation of the original description, and Stephani states distinctly that the species is unknown to him. The original specimens were collected on reeds, but the plant grows preferably on bark.

The most remarkable feature of *C. Jooriana* is its synoicous inflorescence. A paroicous inflorescence occurs in the European *C. microscopica* (Tayl.) Schiffn. and in a few of the larger Lejeuneae and Frullaniae, but a synoicous inflorescence has not before been recorded for any member of the Jubuloideae. In fact the only genera of the leafy hepaticae in which it has been observed are the widely removed *Marsupella* and *Gymnomitrium*, belonging to the Epigoniantheae. In order to see the antheridia of *C. Jooriana*, an unfertilized flower must be examined or one in which the perianth is still very immature. As the perianth develops the antheridia, having carried out their function, shrivel up and are soon difficult to demonstrate. In most flowers antheridia occur only in the axils of the perichaetial bracts, their occurrence in the axil of the subbracteal leaf below the innovation being somewnat unusual.

It is interesting to note that the bracts or at any rate those without innovations exhibit inflated lobules, an indication of their perigonial character.

The hyaline leaf-cells of *C. Jooriana* are also a unique character among our Lejeuneae. On old leaves these cells soon become indistinct, and on poorly developed leaves they may be scanty or wanting, but it is rare to find a plant from which they are altogether absent. Hyaline marginal cells are known in a number of tropical Lejeuneae,* the majority of them being species of *Cololejeunea.* The one most closely allied to *C. Jooriana* is perhaps the autoicous *C. cardiocarpa*, in which the ♂ spike bears six to eight pairs of bracts. In this species also, according to Spruce, the lobule is plane, sublinguiform in shape, obtuse at the apex and almost parallel with the axis.

Of our own species, *C. Jooriana* bears some resemblance to *C. Biddlecomiae* and *C. Macounii.* Aside from its inflorescence and hyaline cells, it differs from both these species in its ordinary leaf-cells which are plane or very slightly convex. It differs also from *C. Biddlecomiae* in its much shorter stylus and from *C. Macounii* in the very different shape of its leaf-lobes.

EXCLUDED SPECIES

The species in the following list have all been recorded from the United States. They are now excluded either because they are imperfectly known or because there is insufficient evidence that they occur within our limits. All of these species are referred to more fully in the preceding text.

1. *Neurolejeunea catenulata* (Nees) Schiffn.
2. *Platylejeunea transversalis* (Swartz) Schiffn.
3. *Archilejeunea Auberiana* (Mont.) Steph.
4. *A. xanthocarpa* (Lehm. & Lindenb.) Steph.
5. *Lopholejeunea Sagraeana* (Mont.) Schiffn.
6. *Acrolejeunea torulosa* (Lehm. & Lindenb.) Schiffn.
7. *Euosmolejeunea trifaria* (Nees) Schiffn.
8. *Pycnolejeunea macroloba* (Mont.) Schiffn.
9. *Lejeunea Caroliniana* Aust.

* *Cf.* Stephani, Hedwigia, 27: 288. 1888.

10. *L. diversiloba* Spruce.
11. *L. flava* Swartz.
12. *L. lacte-fusca* Aust.
13. *L. lacte-virens* Mont.
14. *L. Ravenelii* Aust.
15. *L. Wrightii* Gottsche.
16. *Microlejeunea crenulifolia* Steph.
17. *M. cucullata* (R. Bl. & N.) Jack & Steph.
18. *M. erectifolia* (Spruce) Steph.
19. *M. ulicina* (Tayl.) Evans.
20. *Cololejeunea calcarea* (Lib.) Schiffn.
21. *C. Rossettiana* (Massal.) Schiffn.

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Explanation of Plates

PLATE 16

Archilejeunea clypeata (Schwein.) Schiffn. 1. Stem with perianth, postical view, × 27. 2. Sterile stem, postical view, × 27. 3. Leaf, antical view, × 27. 4. Cells from middle of lobe, × 350. 5. Cells from antical margin of lobe, × 250. 6, 7. Apices of lobules, × 250. 8, 9. Bracts, × 40. 10. Bracteole, × 40. 11. Transverse section of perianth in upper third, × 40. The figures are all drawn from specimens collected by the writer at Woodbridge, Connecticut.

Archilejeunea Sellowiana Steph. 12. Stem with two perianths and ♂ inflorescence, postical view, × 16. 13. Leaf, antical view, × 16. 14. Cells from middle of lobe, × 350. 15. Cells from antical margin of lobe, × 250. 16. Apex of lobule, × 250. 17, 18. Bracts, × 40. 19. Bracteole, × 40. 20. Transverse section of perianth at about the middle, × 40. The figures are all drawn from specimens collected by A. Commons, at Laurel, Delaware (no. 19).

PLATE 17

Archilejeunea conchifolia Evans. 1. Stem with perianth, postical view, × 27. 2. Leaf, antical view, × 27. 3. Cells from middle of lobe, × 350. 4. Cells from antical margin of lobe, × 250. 5. Apex of lobule, × 250. 6, 7. Bracts, × 40. 8. Bracteole, × 40. 9. Transverse section of perianth at about the middle, × 40. The drawings are all made from the type specimens.

Mastigolejeunea auriculata (Wils. & Hook.) Schiffn. 10. Stem with perianth, postical view, × 27. 11. Small branch, postical view, × 27. 12. Leaf, antical view, × 40. 13. Cells from middle of lobe, × 350. 14. Cells from antical margin of lobe, × 350. 15. Apex of lobule, × 50. 16, 17. Bracts, × 40. 18. Bracteole, × 40. 19. Transverse section of perianth at about the middle, × 40. The figures are all drawn from specimens collected by L. M. Underwood in Florida; 11 and 15 came from Orange Bend (no. 1583) and the remainder from Blandton (no. 1988).

PLATE 18

Brachiolejeunea corticalis (Lehm. & Lindenb.) Schiffn. 1. Stem with perianth, postical view, × 31. 2. Leaf, postical view, × 35. 3. Cells from middle of lobe, × 310. 4. Cells from antical margin of lobe, × 220. 5. Free margin of lobule, inner portion, × 220. 6. Free margin of lobule, outer portion, × 220; both from leaf 2. 7, 8. Bracts, × 35. 9. Bracteole, × 35. 10, 11. Transverse sections of perianth, 10 from upper third, 11 from about the middle, × 35. The figures are all drawn from specimens collected at Lake Worth, Florida, by L. M. Underwood (no. 293).

Euosmolejeunea duriuscula (Nees) Evans. 12. Stem with ♀ inflorescence, postical view, × 35. 13, 14. Sterile stems, postical view, × 35. 15, 16. Cells from middle of lobe, × 310. 17. Apex of lobule, × 220. 18, 19. Bracts, × 35. 20. Bracteole from same involucre, × 35. 21–23. Bracts and bracteole from another involucre, × 35. 12, 13, 15, and 17–20 are drawn from Hep. Bor.-Amer. no. 96; 14, 16, and 21–23, from Hep. Amer. no. 97.

PLATE 19

Euosmolejeunea opaca (Gottsche) Steph. 1. Sterile stem, postical view, × 40. 2. Branch with perianth, postical view, × 40. 3. Cells from middle of lobe, × 350. 4. Cells from antical margin of lobe, × 250. 5. Apex of lobule, × 250. 6. Apex of underleaf, × 250 7. Apex of underleaf-segment, × 250. 8, 9. Bracts, × 40. 10. Bracteole, × 40. 11. Transverse section of perianth in upper third, × 40. The figures are all drawn from specimens collected at Enterprise, Florida, by E. Faxon.

Cheilolejeunea polyantha Evans. 12. Stem with perianth, postical view, × 40. 13. Stem with ♀ inflorescence, postical view, × 40. 14. Leaf, antical view, × 40. 15. Cells from middle of lobe, × 350. 16. Apex of lobule, × 250. 17. Apex of underleaf-segment, × 250. 18, 19. Bracts, × 40. 20. Bracteole, × 40. 21. Transverse section of perianth in upper third, × 40. The figures are all drawn from the type-specimens.

PLATE 20

Cheilolejeunea phyllobola (Nees & Mont.) Schiffn. 1. Stem with perianth and ♂ inflorescence, × 40. 2. Cells from middle of lobe, × 350. 3. Cells from antical margin of lobe, × 250. 4. Apex of lobule, × 250. 5. Underleaf, × 60. 6–8. Details of preceding figure 6 representing one side of base, 7 and 8 apices of segments, × 250. 9, 10. Bracts, × 40. 11, 12. Bracteoles, × 40. 13. Transverse section of perianth at about the middle, × 40. The figures are all drawn from specimens collected at Lake Worth, Florida, by L. M. Underwood (no. 301 *p.p.*).

Lejeunea Americana (Lindb.) Evans. 14. Stem with perianth and ♂ inflorescence, postical view, × 40. 15. Sterile stem (a slender form), postical view, × 40. 16. Cells from middle of lobe, × 350. 17. Apex of lobule, × 250. 18. Base of underleaf (one side), × 250. 19–22. Apices of underleaf-segments, × 250. 23, 24. Bracts, × 40. 25. Bracteole, × 40. 26. Transverse section of perianth in upper third, × 40. 2 is drawn from specimens collected by A. B. Langlois near St. Martinsville; the other figures, from specimens collected at Eustis, Florida, by L. M. Underwood (no. 11).

PLATE 21

Microlejeunea lucens (Tayl.) Evans. 1. Stem with ♀ inflorescence, postical view, × 35. 2. Sterile stem, postical view, × 35. 3. Cells from middle of lobe, × 310. 4. Antical base of lobe, × 220. 5. Apex of lobe, × 220. 6. Apex of

lobule, × 220. 7. Stem underleaf, × 220. 8. Branch underleaf, × 220. 9. Bract, × 35. 10. Bracteole, × 35. 2 is drawn from the doubtful type-specimen in the Taylor herbarium (no. 147); the others are all drawn from specimens collected at Manatee, Florida, by L. M. Underwood (no. 305).

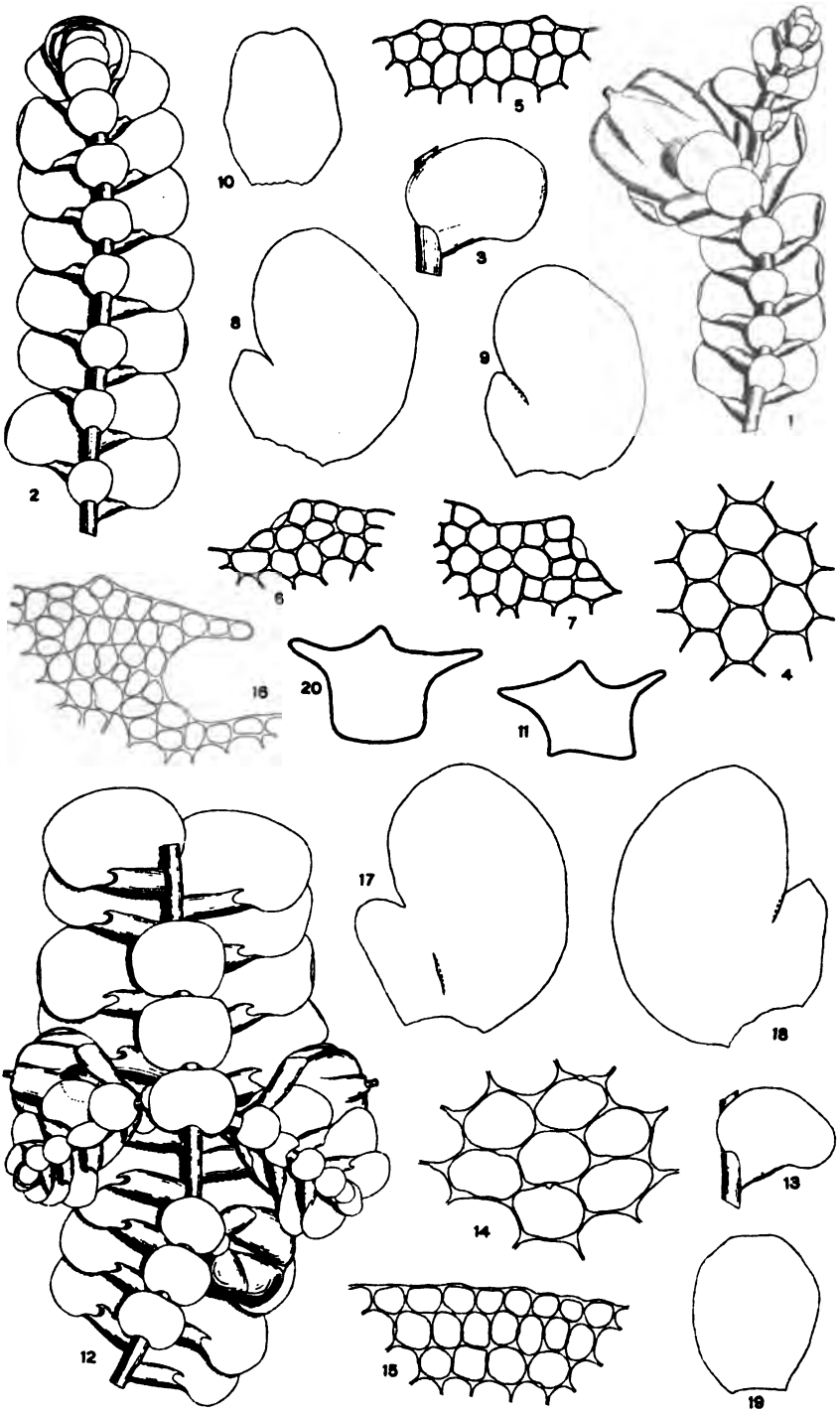
Microlejeunea Ruthii Evans. 11. Stem with ♀ inflorescence, postical view, × 35. 12. Sterile stem, antical view, × 35. 13. Cells from middle of lobe, × 310. 14. Apex of lobe, × 220. 15. Apex of lobule, × 220. 16. Underleaf, × 220. 17, 18. Bracts, × 50. 19. Bracteole, × 50. The figures are all drawn from the type-specimens.

Microlejeunea bullata (Tayl.) Evans. 20. Stem with ♀ inflorescence, postical view, × 50. 21. Sterile stem, antical view, × 50. 22. Branch of 21, antical view, × 50. 23. Cells from middle of lobe, × 310. 24. Antical base of lobe, × 220. 25. Apex of lobule, × 220. 26–28. Underleaves, × 220. 29. Bracts and bracteole, × 50. 20 is drawn from a specimen collected in Florida by J. D. Smith; the remaining figures are drawn from specimens collected at Manatee, Florida, by L. M. Underwood (no. 308).

PLATE 22

Cololejeunea Macounii (Spruce) Evans. 1. Stem with very young perianth, postical view, × 40. 2. Sterile stem, postical view, × 40. 3. Cells from middle of lobe, × 350. 4. Similar cells in cross-section, × 350. 5. Cells from margin of lobe, × 250. 6. Apex of lobule, × 250. 7, 8. Bracts, × 40. The figures are all drawn from specimens collected in British Columbia by J. Macoun.

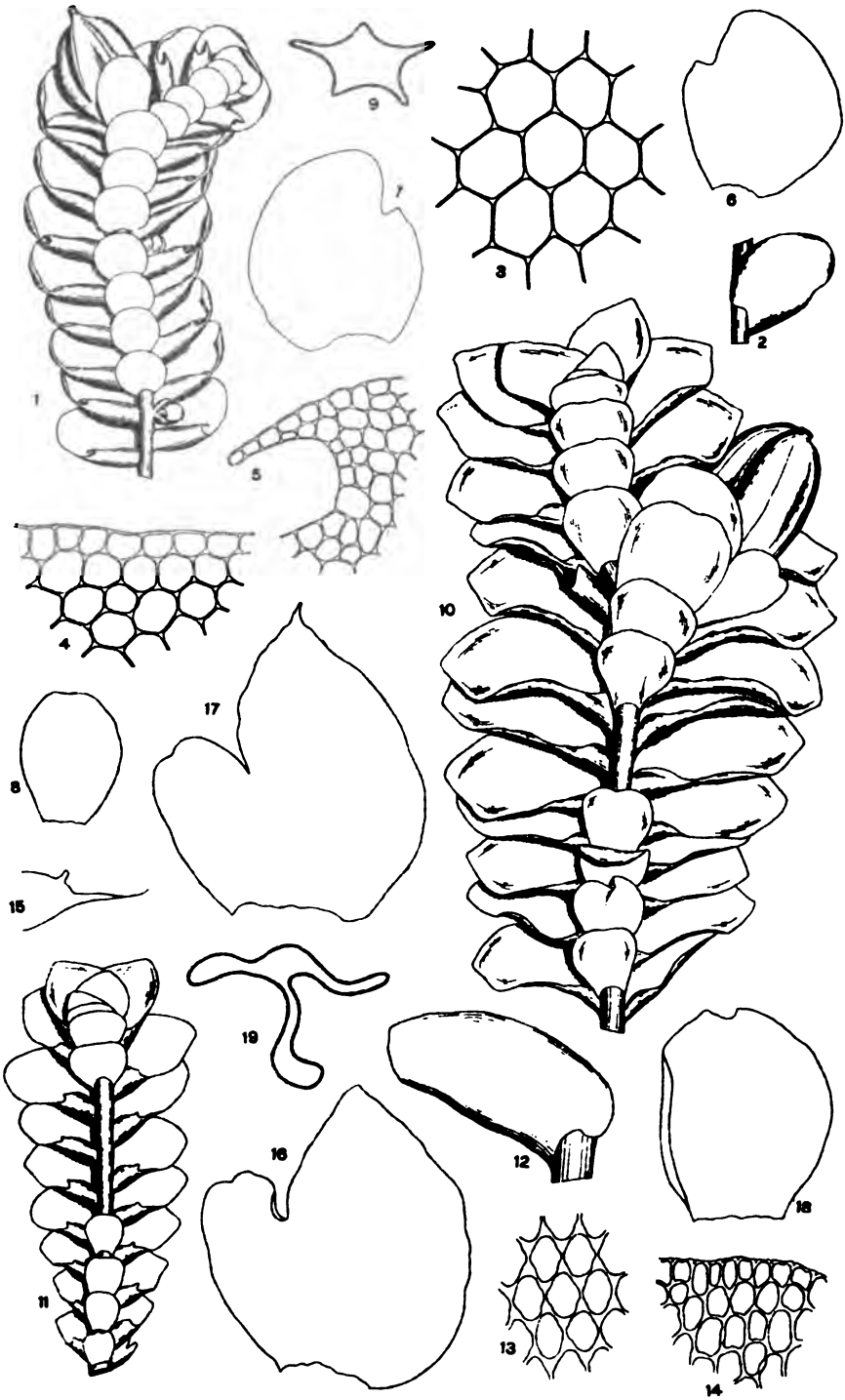
Colo ejeunea Jooriana (Aust.) Evans. 9. Stem with perianth and bisexual inflorescence, postical view, × 40. 10. Stem with perianth on a short branch, postical view, × 40. 11. Two leaves, antical view, × 40. 12. Cells from middle of lobe, × 350. 13. Cells from antical margin of lobe, × 250. 14–16. Apices of lobes, × 250. 17. Apex of lobule, × 250. 18, 19. Bracts, × 40. 20. Transverse section of perianth in upper third, × 40. The figures are all drawn from specimens collected at Lisbon Florida, by L. M. Underwood (no. 100).



1-11-ARCHILEJEUNEA CLYPEATA (Schwein.) Schiffn.

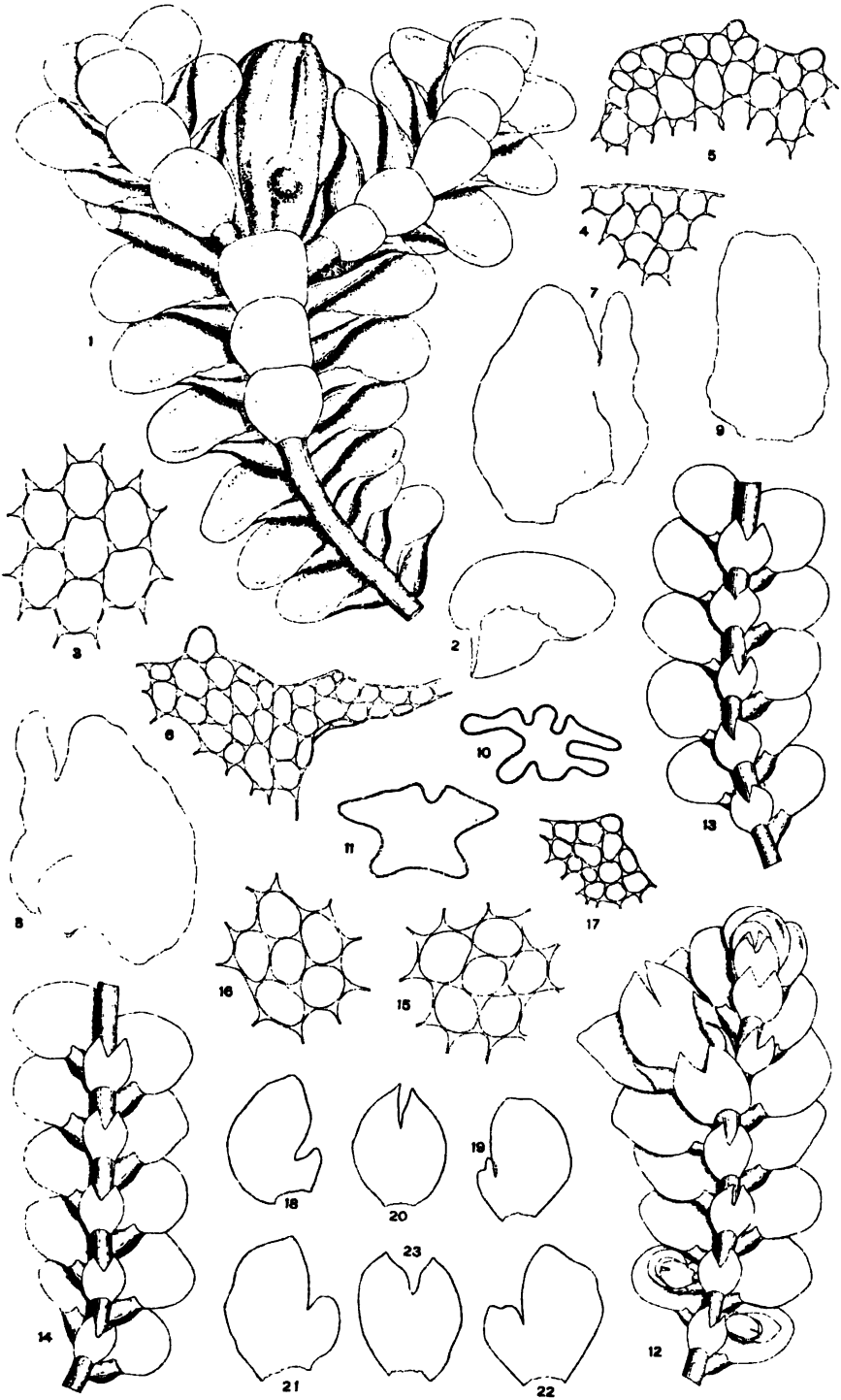
12-20-ARCHILEJEUNEA SELLOWIANA Steph.

HELIOTYPE CO., BOSTON



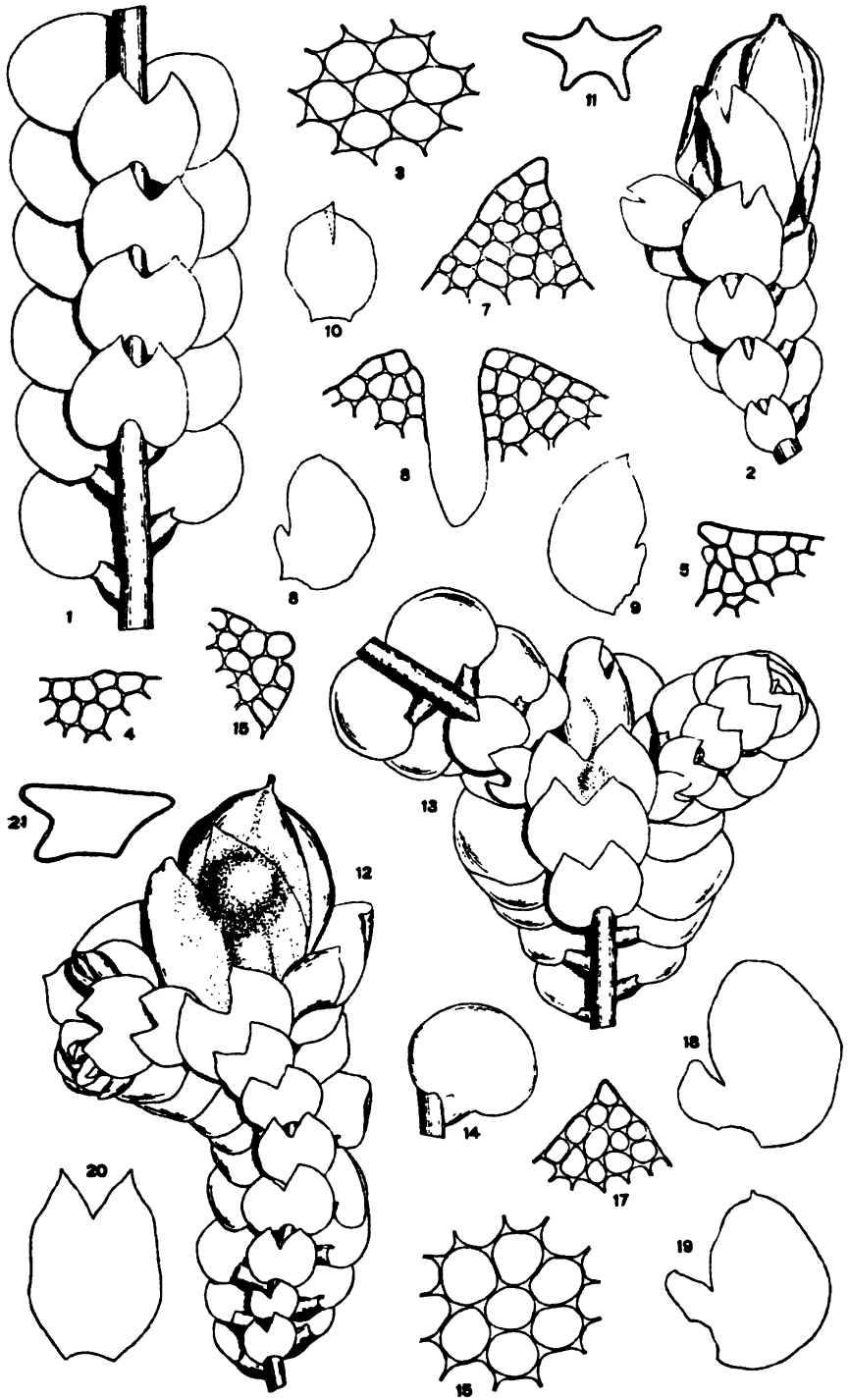
1-9-ARCHILEJEUNEA CONCHIFOLIA Evans

10-19-MASTIGOLEJEUNEA AURICULATA (Wils. & Hook.) Schiffn.



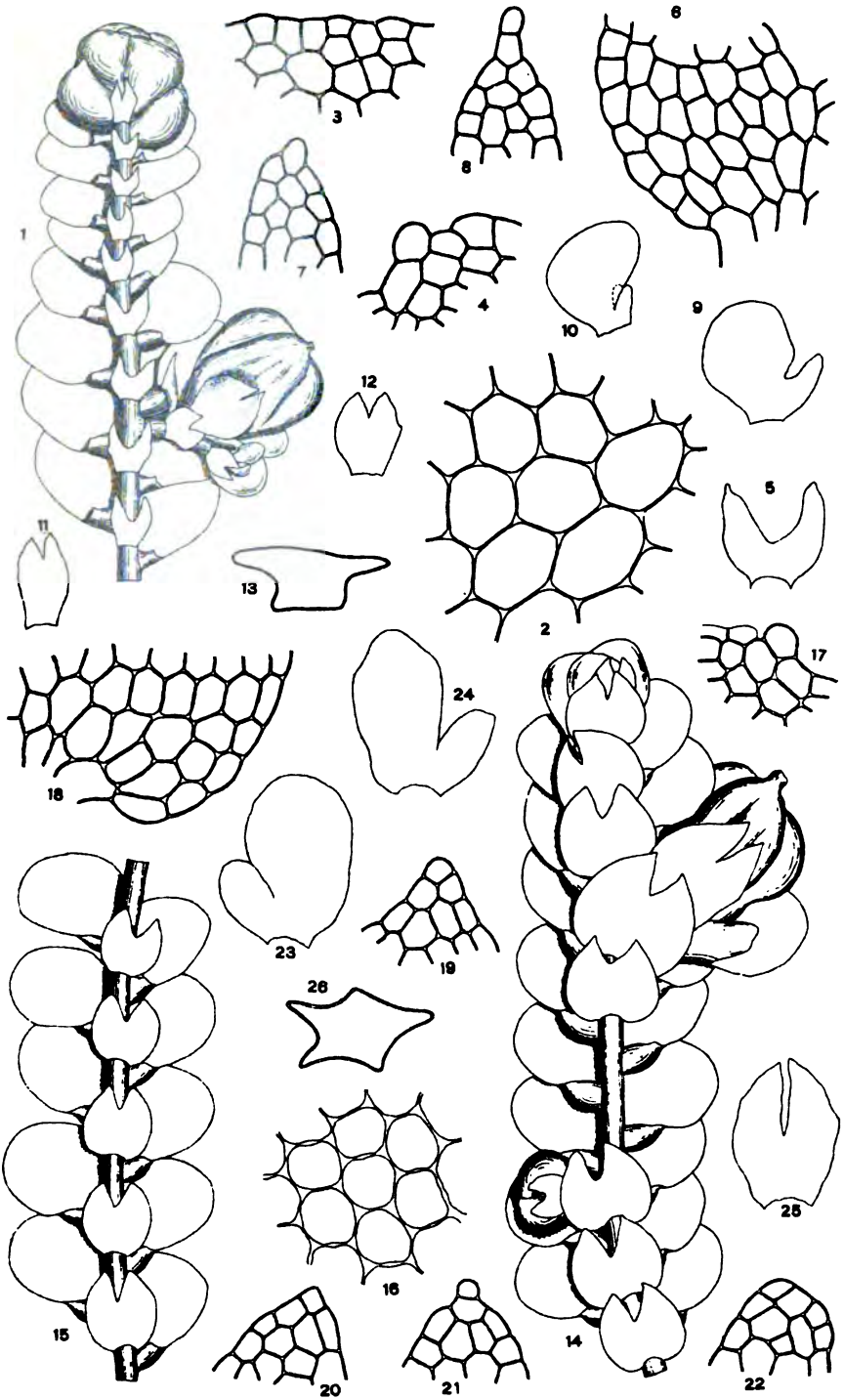
1-11-BRACHIOLEJEUNEA CORTICALIS (Lehm. & Lindenb.) Schiffn.

12-23-EUOSMOLEJEUNEA DURIUSCULA (Nees) Evans.



1-11-EUOSMOLEJEUNEA OPACA (Gottsche) Steph.

12-21-CHEILOLEJEUNEA POLYANTHA Evans



1-13-CHEILOLEJEUNEA PHYLLOBOLA (Nees & Mont.) Schiffn.

14-26-LEJEUNEA AMERICANA (Lindb.) Evans

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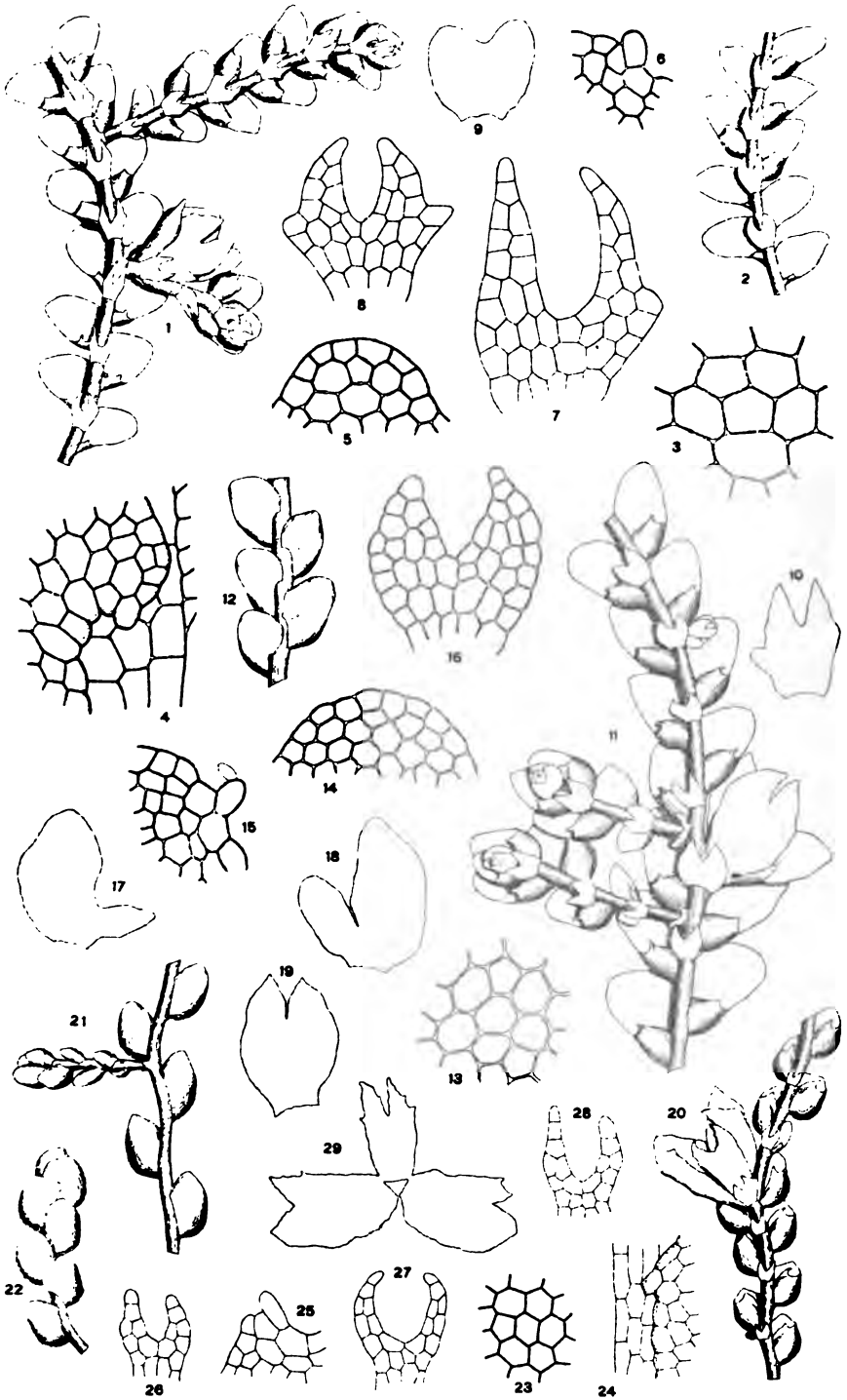
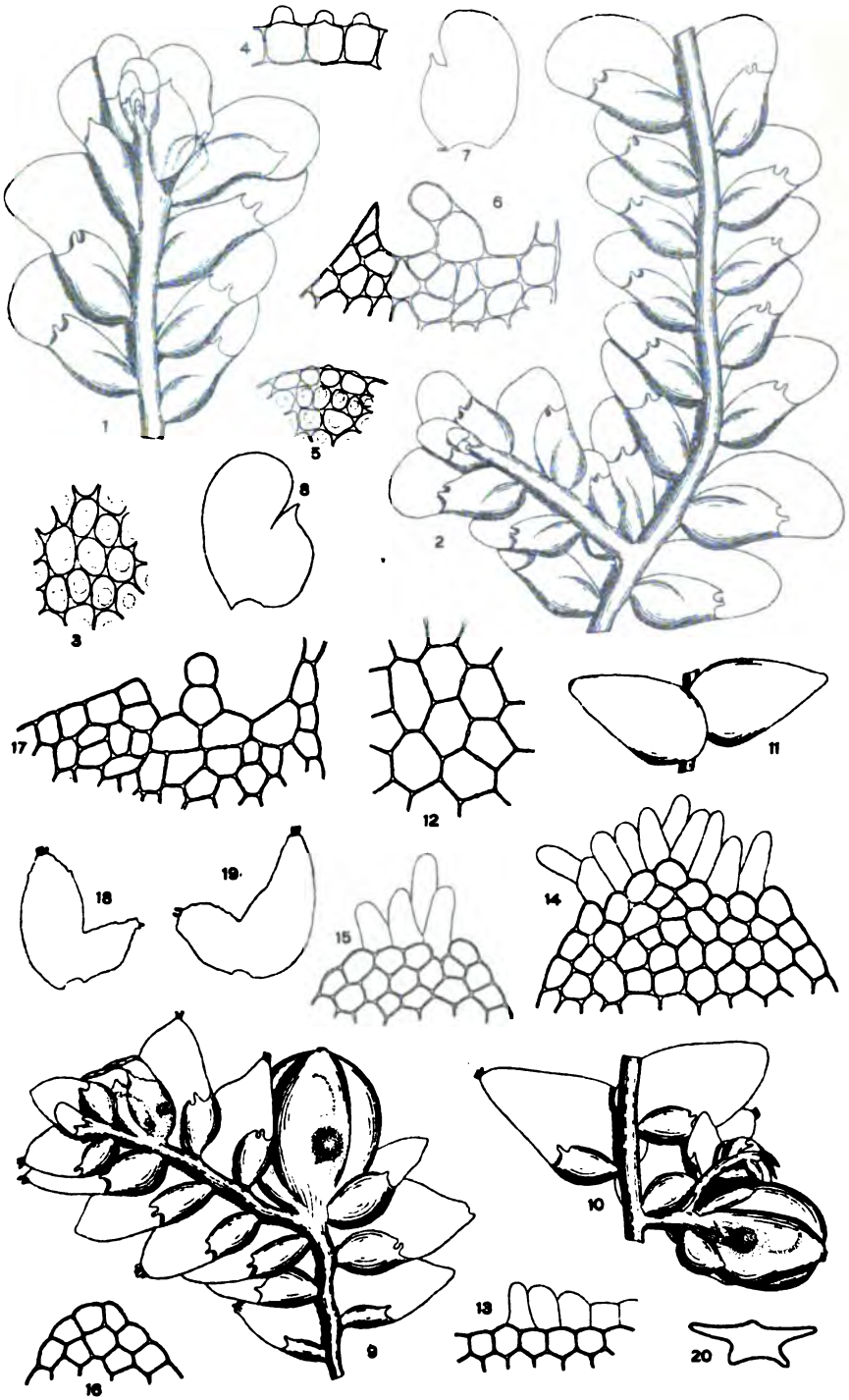


1-10-MICROLEJEUNEA LUCENS (Tayl.) Evans

11-19-MICROLEJEUNEA RUTHII Evans

20-29-MICROLEJEUNEA BULLATA (Tayl.) Evans



1-8-COLOLEJEUNEA MACOUNII (Spruce) Evans

9-20-COLOLEJEUNEA JOORIANA (Aust.) Evans

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INDEX TO SPECIES

Species described are in SMALL CAPITALS, the page at which the description occurs being in full face type; species cited without description in Roman type; synonyms in *Italics*.

Acrolejeunea (Spruce) Schiffn.
torulosa (Lehm. & Lindenb.) Schiffn., 115, 175
ARCHILEJEUNEA (Spruce) Schiffn.
Auberiana (Mont.) Steph., 115, 175
CLYPEATA (Schwein.) Schiffn., 114, 119, 122, 178
CONCHIFOLIA Evans, 128, 178
SELLOWIANA Steph., 116, 119, 125, 178
xanthocarpa (Lehm. & Lindenb.) Steph., 117, 127, 175

BRACHIOLEJEUNEA (Spruce) Schiffn.
bicolor (Nees) Schiffn., 133
CORTICALIS (Lehm. & Lindenb.) Schiffn., 131, 179

CHEILOLEJEUNEA (Spruce) Schiffn.
duriuscula Schiffn. = Euosmolejeunea duriuscula
emarginuliflora (Gottsche) Schiffn., 147
PHYLLOBOLA (Nees & Mont.) Schiffn., 143, 144, 145
PILILOBA (Spruce) Evans, 147, 148
POLYANTHA Evans, 141, 179
VERSIFOLIA (Gottsche) Schiffn., 144, 145
COLOLEJEUNEA (Spruce) Schiffn.
BIDDLECOMIAE (Aust.) Evans, 115, 117, 119, 168, 169, 170, 171, 172, 175
calcarea (Lib.) Schiffn., 115, 170, 176
cardiocarpa (Mont.) Evans, 172, 173, 175
JOORIANA (Aust.) Evans, 116, 120, 168, 173, 174, 174, 175, 180
MACOUNII (Spruce) Evans, 117, 119, 120, 127, 171, 172, 175, 180
microscopica (Tayl.) Schiffn., 174
MINUTISSIMA (Smith) Schiffn., 114, 117, 165, 166, 167, 168
platyneura (Spruce) Evans, 172, 173
Rossettiana (Massal.) Schiffn., 117, 171, 176

Eulejeunea (Spruce) Schiffn. = Lejeunea
serpyllifolia Schiffn. = Lejeunea cavifolia
EUOSMOLEJEUNEA (Spruce) Schiffn.
DURIUSCULA (Nees) Evans, 114, 116, 117, 118, 135, 142, 144, 145, 156, 157, 179
OPACA (Gottsche) Steph., 116, 118, 139, 142, 179
trifaria (Nees) Schiffn., 115, 118, 140, 175

Frullania Raddi
Bolanderi Aust., 146
Leprieurii Mont. = Brachiolejeunea corticalis
Virginica Gottsche, 114

HARPALEJEUNEA (Spruce) Schiffn.
OVATA (Hook.) Schiffn., 116, 119, 133
Hygrolejeunea (Spruce) Schiffn.
phyllobola Massal. = Cheilolejeunea phyllobola

Jungermannia L.
auriculata Wils. & Hook. = Mastigolejeunea auriculata
cavifolia Ehrh. = Lejeunea cavifolia
clavaeflora Nees = Lejeunea cavifolia
clypeata Schwein. = Archilejeunea clypeata
corticalis Lehm. & Lindenb = Brachiolejeunea corticalis
cucullata R. Bl. & Nees = Microlejeunea cucullata
inconspicua Raddi = Cololejeunea minutissima
lucens Tayl. = Microlejeunea lucens
minutissima Smith = Cololejeunea minutissima
parvula Wils. & Hook. = Cololejeunea minutissima
serpyllifolia Dicks. = Lejeunea patens
transversalis Schwein. = Archilejeunea clypeata
transversalis Sw. = Platylejeunea transversalis
xanthocarpa Lehm. & Lindenb. = Archilejeunea xanthocarpa

Kantia S. F. Gray
aquatica Underw., 153

LEJEUNEA Lib.
AMERICANA (Lindb.) Evans, 114, 118, 120, 152, 154, 155, 156, 157, 179
auriculata Sull.=Mastigolejeunea auriculata
Austini Lindb. = Euosmolejeunea duriuscula
Biddlecomiae Aust. = Cololejeunea Biddlecomiae
biseriata Aust. = a moss
bullata Tayl. = Microlejeunea bullayt
calcarea Lib. = Cololejeunea calcaraa
calyculata Tayl. = Archilejeunea clepeata
Cardoti Steph. = Microlejeunea Cardoti
Carolinensis Mont. = Archilejeunea clypeata
Caroliniana Aust., 116, 175
catenulata Nees = Neurolejeunea catenulata
CAVIFOLIA (Ehrh.) Lindb., 114, 119, 139, 144, 151, 152, 153, 156, 157
clausa Nees & Mont., 141
clypeata Sull. = Archilejeunea clypeata
contigua Nees, 142
corticalis Steph. = Brachiolejeunea corticalis
crenulifolia Gottsche = Microlejeunea crenulifolia
cucullata Nees = Microlejeunea cucullata
diversifolia Gottsche = Microlejeunea erectifolia
diversiloba Spruce, 160, 176
Dorotheae Lehm. = Archilejeunea clypeata
duriuscula Nees = Euosmolejeunea duriuscula
echinata Tayl. = Cololejeunea calcarea
erectifolia Spruce = Microlejeunea erectifolia
flava Sw., 118, 137, 176
flexuosa Lindenb. = Euosmolejeunea duriuscula
inconspicua DeNot. = Cololejeunea minutissima
Jooriana Aust. = Cololejeunea Jooriana
laete-fusca Aust., 116, 176
laete-virens Mont., 116, 176
linguaefolia Tayl. = Brachiolejeunea corticalis
longiflora Tayl. = Euosmolejeunea trifaria
LEJEUNEA Lib.
lucens Tayl. = Microlejeunea lucens
Macounii Spruce = Cololejeunea Macounii
Mohrii Aust.= Euosmolejeunea opaca
Molleri Steph. = Harpalejeunea ovata
minutissima Dumort. = Cololejeunea minutissima
opaca Gottsche = Euosmolejeunea opaca
ovata Tayl. = Harpalejeunea ovata
oxyloba Lindenb. & Gottsche, 145
parvula Aust. = Cololejeunea minutissima
PATENS Lindb., 119, 120, 149, 150, 151, 152, 153
phyllobola Nees & Mont. = Cheilolejeunea phyllobola
pililoba Spruce = Cheilolejeunea pililoba
polyphylla Tayl. = Acrolejeunea torulosa
pulvinata Lehm. & Lindenb., 137
Ravenelii Aust., 116, 176
Rossettiana Massal. = Cololejeunea Rossettiana
serpyllifolia Lib. = Lejeunea cavifolia
setiloba Spruce, 148
Sullivantiae Aust. = Euosmolejeunea duriuscula
Sullivantii Gottsche, 117, 137
Taylori Spruce = Cololejeunea minutissima
thymifolia Nees = Lejeunea flava
transversalis Sw. = Platylejeunea transversalis
trifaria Nees = Euosmolejeunea trifaria
ulicina Tayl. = Microlejeunea ulicina
Underwoodii Steph. = Euosmolejeunea duriuscula
velata Gottsche = Archilejeunea Sellowiana
versifolia Gottsche = Cheilolejeunea versifolia
Wrightii Gottsche, 118, 176
xanthocarpa Lehm. & Lindenb. = Archilejeunea xanthocarpa
Lopholejeunea (Spruce) Schiffn.
Sagraeana (Mont.) Schiffn., 115, 175

MASTIGOLEJEUNEA (Spruce) Schiffn.
AURICULATA (Wils. & Hook.) Schiffn., 114, 129, 178
humilis (Gottsche) Schiffn., 131
repleta (Tayl.) Evans, 129, 131
MICROLEJEUNEA (Spruce) Jack & Steph.
BULLATA (Tayl.) Evans, 164, 165, 167, 180

MICROLEJEUNEA (Spruce) Jack. & Steph.
CARDOTI (Steph.) Evans, 118, 162, 163
crenulifolia Steph., 160, 176
cucullata (R. Bl. & Nees) Jack & Steph., 115, 159, 160, 176
erectifolia (Spruce) Steph., 160, 176
LUCENS (Tayl.) Evans, 116, 144, 145, 156, 157, 159, 162, 164, 179
RUTHII Evans, 119, 161, 162, 164, 180
ulicina (Tayl.) Evans, 117, 162, 165, 167, 176
Neurolejeunea (Spruce) Schiffn.
catenulata (Nees) Schiffn., 115, 127, 175
Pandu/phinius S. F. Gray = Lejeunea *serpyllifolius* S. F. Gray = Lejeunea patens
Phragmicoma Dumort. = Marchesinia
corticalis Lehm. & Lindenb. = Brachiolejeunea corticalis
clypeata Nees = Archilejeunea clypeata
cyclostipa Tayl. = Archilejeunea Auberiana + Lopholejeunea Sagraeana
Leprieurii Mont. = Brachiolejeunea corticalis
ligulata Lehm. & Lindenb. = Mastigolejeunea ligulata Schiffn., 129
Phragmicoma Dumort. = Murchesinia
melanophloea Mont. & Nees = Brachiolejeunea corticalis
repleta Tayl. = Mastigolejeunea repleta
teretiuscula Lindenb. & Gottsche *p. p* = Mastigolejeunea auriculata
testudinea Tayl. = Pycnolejeunea macroloba
versicolor Lehm. & Lindenb. *p. p.* = Mastigolejeunea auriculata
xanthocarpa Aust. = Archilejeunea Sellowiana
Platylejeunea (Spruce) Schiffn.
transversalis (Sw.) Schiffn., 114, 115, 175
Ptychocoleus Trevis.
auriculatus Trevis. = Mastigolejeunea auriculata
corticalis Trevis. = Brachiolejeunea corticalis
Pycnolejeunea (Spruce) Schiffn.
macroloba (Mont.) Schiffn., 115, 175
papulosa Steph., 142
Radula Dumort
tenax Lindb., 114
Symbiezidium Trevis.
calyculatum Trevis. = Archilejeunea clypeata

The Life History of Vittaria lineata

By Elizabeth G. Britton and Alexandrina Taylor

(Plates 23–31)

At the conclusion of our studies on *Schizaea pusilla*, Mr. Tracy Hazen called our attention to the fact that Francis Wolle* had figured a filamentous protonema, which he suspected to belong to a fern, but had previously described as *Poterophora Donnellii*.† It was collected on trees in Florida by John Donnell Smith who loaned us the type from which drawings have been made, as the figures given by Wolle were found to be incorrect. The urns described by Wolle are podetia and produce spherical or cylindric gemmae which Wolle did not figure. This curious method of vegetative propagation has been figured by Goebel‡ in a species of *Trichomanes*, but as the sporophyte is still unknown in *Poterophora* and we knew of no epiphytal species of *Trichomanes* in Florida, suspicion was aroused regarding *Vittaria lineata*. Living plants in all stages were secured from E. W. Reasoner, of Oneco, Florida, and also from Miss Abbie M. Small at Jacksonville, Florida. We have kept these plants growing in the laboratory for more than a year, and watched the stages of their development. As far as we can learn, the gametophyte of this fern has never been described; in fact the only reference to it is in a footnote in Eaton's Ferns of North America, which states that "J. Donnell Smith and C. F. Austin found the prothalline growth of this fern very abundant on palmettos along the Caloosahatchie River, Florida." The peculiarities of its structure are remarkable, agreeing in essential particulars with those of *Vittaria elongata*, described by Goebel from specimens studied at the Botanical Gardens at Buitenzorg, Java.§

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* F. Wolle, F. W. Algae of N. A. 120. *pl. 106.* 1887.

† Bull. Torrey Club, **6**: 177, 188. 1877.

‡ Goebel, Ann. Jard. Buit 7: 78–87. *pl. 10–13.* 1888.

§ Goebel, Ann. Jard. Buit. 7: 95. *pl. 12, f. 60–61.*

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[No. 3 issued 30 August, 1902.]

The systematic records of *Vittaria lineata* were also found to be very imperfect; specimens were much mixed in our collections and several other closely allied species had been mistaken for this species. The types of several of these need to be restudied microscopically before we can reach a correct knowledge of the limits and distribution of the American species. The material in American collections is necessarily incomplete, and the types are scattered through European herbaria. However, with what specimens and literature are available, we believe it will be helpful to give a brief survey of the history of *Vittaria lineata*, and to describe and figure the gametophyte of our specimens from Florida. It would be still more helpful if collectors in the West Indies would make it a point to collect the prothallia and young stages of *Vittaria*, and preserve them in condition for study.

The genus *Vittaria* is in need of revision, as there has been none made since that of Fée,* and subsequent treatment in the Synopsis Filicum has largely disregarded the results attained in his memoir. Kunze and Fée were the first to recognize the value of the spores and sporangiasters in specific distinctions, and Fée also figured the scales and sporangia, although in many species the lip cells were omitted. The venation is obscure in many species, and in consequence has been wrongly described. *Taenitis* has been combined with *Vittaria* by some authors which tends to complicate the synonymy, and *Taeniopsis* was founded on the type species of *Vittaria*.†

The most recent list given of the species is that of Salomon ‡ from which the following has been compiled, but it will be found that a number of corrections have been made after consulting the original place of publication.

CHRONOLOGICAL LIST OF THE AMERICAN SPECIES

1753. *Pteris lineata* L. Sp. Pl. 1073.
1801. *Vittaria filiformis* Cav. Praelect. 270 (671).
1803. *V. angustifrons* Michx. Flor. bor. Am. **2**: 261.
1819. *V. Schkuhrii* Raddi, Fil. Bras. 51.

* Fée, Mem. des Foug. **3**: 1–24. 1851.
† J. Smith, Hook. Journ. Bot. **4**: 67. 1842.
‡ Salomon, Nom. Gefäss.-Krypt. 1883.

1824. *V. graminifolia* Kaulf. Enum. Fil. 192.
1837. *V. stipitata* Kze. Analect. pteridogr. 28. *pl. 18. f. 1.*
1851. *V. Gardneriana* Fée, Mem. des Foug. **3**: 15. *pl. 3. f. 1.*
1851. *V. filifolia* Fée, Mem. des Foug. **3**: 20. *pl. 3. f. 6.*
1851. *V. Ruiziana* Fée, Mem. des Foug. **3**: 16. *pl. 3. f. 3.*
1851. *V. scabrida* Klotsch; Fée, Mem. des Foug. **3**: 20.
1854. *V. remota* Fée, Mem. des Foug. **7**: 26. *pl. 20. f. 1.*
1854. *V. curvidentata* CM. Bot. Zeitung, **12**: 546. *pl. 13. f. 1.*
1854. *V. dimorpha* CM. *l. c.* 547. *pl. 13. f. 3.*
1854. *V. pachydictyon* CM. *l. c.* 547. *pl. 13. f. 4.*
1854. *V. Deppeana* CM. *l. c.* 547. *pl. 13. f. 6.*
1864. *V. Karsteniana* Mett. Ann. Sc. Nat. V. **2**: 206.
1864. *V. Moritziana* Mett. *l. c.*, 207.
1869. *V. Orbignyana* Mett. Linnaea, **36**: 67.
1869. *V. gracilis* Moritz, Linnaea, **36**: 67.
1877. *V. intramarginalis* Baker, Journ. Bot. **15**: 266.
1893. *V. longipes* Sodiro, Crypt. Vasc. Quit. 423.

Of these *V. filiformis*, *V. angustifrons*, *V. Schkuhrii* and *V. curvidentata* have been referred to *V. lineata* as synonyms, and *V. graminifolia* has been reduced to a variety of both *V. lineata* and of *V. curvidentata.* Mettenius * expressed the opinion that *V. graminifolia* and *V. filifolia* were the same species, and figured *V. filifolia* with a cross-section of the leaf. The type of *V. graminifolia* should be found either at the University of Leipzig or in the herbarium of Count du Roemer at Dresden and the type of *V. filifolia* in the Cosson herbarium at Paris. Fée says it is remarkable for its long stipe. *V. Gardneriana* and *V. remota* are too closely allied and need more study; *V. Ruiziana* is said to be a synonym of *V. Moritziana* by Mettenius and if so has priority over that species; *V. scabrida* has not been figured, and is apparently closely related to *V. dimorpha* in size; *V. Deppeana* has been referred to *V. filifolia*, by Mettenius, but is apparently distinct; *V. gracilis* and *V. intramarginalis* should be compared with *V. filifolia;* and *V. longipes* should be compared with *V. Orbignyana.*

Karl Müller † has shown that the character of the scales surrounding the base of the leaves vary in different species, and may

* Mett. Fil. Hort. Bot. Lips. 25–27. *f. 21, 22.* 1856.
† Bot. Zeitung, **12**: 537–548. *pl. 13.* 1854.

be either entirely parenchymatic, or the cell walls may be thickened evenly, or even papillose. This character he made use of in describing six new species, but he ignored the spores and paraphyses, so that it is hard to compare his species with those described and figured by Fée. Luerssen * followed Mettenius in reducing *V. Deppeana* to *V. filifolia*, in spite of the differences of the scales as figured by Müller, and maintained *V. curvidentata* to which he referred *V. graminifolia* as a variety.

GEOGRAPHICAL DISTRIBUTION

In the following list the type locality is given first, and then the distribution as cited by Fée, the authors of the species and subsequent lists, without any attempt to verify the determinations:

V. lineata, Haiti; West Indies, North and South America, East Indies (?).

V. graminifolia, Brazil; Peru, Mexico.

V. stipitata, Peru; West Indies and South America.

V. Gardneriana, Brazil; South America and Mexico.

V. filifolia, Mexico; Central and South America, West Indies.

V. Ruiziana, Peru and South America. (*V. Moritziana*, Peru.)

V. scabrida, Brazil; Mexico.

V. remota, New Granada, South America and West Indies.

V. Karsteniana, United States of Colombia.

V. gracilis, United States of Colombia.

V. Orbignyana, Bolivia.

V. longipes, Ecuador.

V. intramarginalis, Jamaica.

V. dimorpha, Mexico.

V. curvidentata, Brazil.

V. pachydictyon, South America, Surinam.

V. Deppeana Mexico.

Leaving out of consideration the South American species, it will be found that ten of the above species have been reported from Mexico and the West Indies. Of these the Mexican species are most interesting and need revision. *V. scabrida* and *V. Deppeana* have not been seen in any American herbarium. In *V. scabrida* Fée † gives the length as 90 cm.; this is probably a mis-

* Luerssen, Fil. Graeff. 92–94. 1871.

† Fée, Mem. des Foug. 3: 20. 1852.

take for he says it is a small species with short fronds, and it is described in the Synopsis Filicum as two inches long, and Sodiro † says the leaves are 2–6 inches. Specimens labeled *V. dimorpha* collected by F. Müller in 1848–1855, at Orizaba, are in the Columbia University herbarium, but do not answer to the description of this species. Fournier ‡ credits *V. lineata*, *V. gramifolia* and *V. scabrida* to Mexico, and Fée § lists *V. filifolia* from several Mexican localities and collectors.

We have not studied the Central American species, but we find among the specimens distributed by J. Donnell Smith as *V. lineata*, that no. 811, collected by Turckheim in Guatemala is *V. filifolia* and that no. 7489 collected by H. Pittier in Costa Rica, is probably *V. graminifolia*.

Grisebach || records only one species, *V. lineata*, from the West Indies, which he says occurs in Jamaica, St. Vincent and Barbadoes. Charles Wright collected in Cuba as no. 865, in 1856, two species, *V. filifolia* and *V. lineata*, which were distributed as one. No. 865, of his collection of 1865, is *V. stipitata*. Kunze ¶ records *V. graminifolia* from Cuba.

V. Gardneriana has been collected in Puerto Rico by Blauner and Sintenis, and *V. remota* has also been credited to Puerto Rico. Fée** has reported *V. filifolia* from that Island and *V. lineata* was collected by Sintenis.

Jenman †† has described *V. lineata*, *V. stipitata*, *V. remota* and *V. intramarginalis* from Jamaica: the last a new species closely allied to *V. filifolia*, judging by the description and specimens received from B. D. Gilbert; it has triangular spores, but the paraphyses have not been seen. *V. remota* is described as having the venation anastomosing once besides the normal marginal one; this does not agree with Fée's ‡‡ figures, in which the venation is oblique as in *V. Gardneriana*.

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† Sodiro, Crypt. Vasc. Quit. 423. 1893.

‡ Fournier, Miss. Scient. au Mex. et Am. Cent. 114. 1872.

§ Fée, Mem. des Foug. 3: 15. 1852; 11, 13. 1866.

|| Grisebach, Flora of the West Indies, 674. 1864.

¶ Kunze, Syn. Plant. Crypt. Poepp., Linnaea, 9: 76, 77. 1833.

** Fée, Mem. 11: 13. 1866.

†† Jenman, Syn. List of Jamaica Ferns. Bull. Bot. Dept. Jam. 4: 212. 1897.

‡‡ Fée, Mem. 7: 26. *pl. 30. f. 1.*

Haiti is the type locality for *V. lineata*, but we have never seen a specimen of *Vittaria*, from Haiti or Santo Domingo. Specimens were distributed from Berlin, determined by Kuhn as *V. graminifolia* var. *filifolia* collected by Hahn on Martinique. *V. filifolia* has been credited by Fée to Guadeloupe collected by L'Herminier, and *V. lineata* was collected on Trinidad by Fendler. A dwarf form of *V. lineata* also occurs in the Bahamas. Mr. Britton has collected sterile specimens of *V. filifolia* on St. Kitts.

HISTORY OF THE GAMETOPHYTE

The statement has been made that the gametophyte of *Vittaria lineata* has not been described, and so far as we knew, the gametophyte was unknown in all the other American species. Professor Underwood has called our attention to a copy of Lindenberg's monograph of the Ricciaccae * which formerly belonged to Austin, in which Austin had written opposite the description of *Riccia reticulata*, "a species of *Vittaria*." Lindenberg had classed it among the "*Species dubiae*." *Riccia reticulata* was described by Swartz † as having the fronds laciniate, glabrous and reticulate. He referred to it specimens from the Island of [New?] Providence described by Dillenius ‡ as *Lichenoides gelatinosus tenue reticulatum*. Swartz § stated that it grew on trees covered with mosses in the mountains of Jamaica, and described it as follows:

RICCIA ? RETICULATA. "Frons membranacea, plana, difformis, lobata, laciniata, latitudine unciales, laciniis linearibus, saepe bipartitis, pollicaribus, glabra, obscure viridis, tenuissime reticulato-venosa. Obs. Ob texturam teneriorem Hepaticis conjungere malui quam Lichenibus." The illustration given by Dillenius is simply an outline, but the figure and description given by Lindenberg agree exactly with no. 327 from St. Kitts, collected by Mr. Britton in 1901, which he also took for a hepatic. It proves to be the gametophyte of a species of *Vittaria*, probably *V. filifolia*, the leaves of which were collected in another ravine but were not

* J. B. W. Lindenberg, Mon. Ricc. 501. *pl. 36. f. 1–4.* 1836.
† Swartz, Prod. Ind. Occ. 146. 1788.
‡ Dillenius, Hist. Musc. 1: 138. *pl. 19. f. 21.* 1741.
§ Sw. Fl. Ind. Occ. 3: 1883. 1806.

found with or near no. 327. This implies an independent existence for the gametophyte, which agrees with that of *V. lineata* in being proliferous by its septate gemmae and in being lobed, but it differs in the shape and size of the thallus, the shape of the lobes, and the cellular structure. However, the specimens were dried when examined, as were Lindenberg's, whose description and figures were drawn from the type of *Riccia reticulata*, belonging to Swartz, which had been collected thirty years at the time the drawings were made. The cell contents had shrunk, forming a fine mesh of the strings of protoplasm, radiating from the nucleus of each cell, which gave the dotted and reticulated appearance described by Swartz as visible with a hand lens. The gemmae also must have disappeared, for they are neither figured nor described. In the specimen from St. Kitts, they are most abundant on the truncate ends of the long, narrow lobes.

That the gametophyte of *Vittaria* maintains an indefinite and independent existence, without forming the sporophyte, seems to be an established fact. It is autoicous, the archegonia being borne mostly on the thallus, and the antheridia on the gemmae. In a climate where violent winds and heavy rains are frequent the gemmae would be liable to be detached without fertilization having taken place. Dr. Campbell reports having seen in Jamaica, enormous sterile prothallia, forming circular mats at least three inches in diameter on the trunks of palms, and resembling a liverwort. Dr. Campbell * has also described and figured a prothallium collected in the Sandwich Islands, similar to that of *Vittaria*, which he has referred to a species of *Hymenophyllum*. He states that they lived for two or three years in his laboratory. He also states that "Goebel has described in *Vittaria* a type of prothallium recalling that of *Hymenophyllum*, both in its large size and extensive branching." From our present knowledge we are inclined to believe that Campbell has mistaken the genus, and that these prothallia should be referred to *Vittaria*, probably to *V. elongata*.

* Campbell, Mosses and Ferns, 362. *f. 187, 188.* 1895.

Synopsis of the North American Species of Vittaria*

Stipes green; 1–2 cm. long, margins recurved when dry.
Spores reniform, paraphyses enteriform; scales papillose, serrate.
Leaves 30–120 cm. long, 2–3 mm. wide, pendent. *V. lineata.*
Leaves 10–15 cm., narrowly linear, erect. *V. graminifolia.*
Spores tetrahedral; scales smooth. *V. intramarginalis.*
Stipes green or yellow, 10–15 cm. long; margins revolute.
Spores tetrahedral, paraphyses mastoid-claviform, scales smooth, entire. *V. filifolia.*
Spores tetrahedral?; paraphyses enteriform?; scales papillose, aristate, serrate. *V. Deppeana.*
Stipes green, short; leaves 4–16 cm. long.
Spores tetrahedral; paraphyses cucullate; scales dentate. *V. scabrida.*
Spores ?; paraphyses ?; scales aristate, papillose, entire. *V. dimorpha.*
Stipes brown or black, 2–9 cm. long; margins flat; spores reniform.
Leaves 20–30 cm. long; paraphyses cyathiform.
Leaves 7–9 mm. wide; rhizome creeping. *V. Gardneriana.*
Leaves 6–12 mm. wide; rhizome erect. *V. remota.*
Leaves 1 meter long, 3–5 mm. wide; paraphyses pyriform. *V. stipitata.*

VITTARIA LINEATA (L.) J. E. Smith.

Lingua cervina longissimus & angustissimis foliis. Plumier Fil. Am. 123. *pl. 143.* 1705.

Phyllitis lineata, graminis folio longissimo. Pet. Fil. 126. *pl. 14.* 1712.

Pteris lineata L. Sp. Pl. 1073. 1753.

Vittaria lineata J. E. Smith, Mem. Acad. Roy. Sci. Turin. **5**: 413. 1793.

V. lineata Swartz, Schrad. Journ. **2**: 72. 1800; Syn. Fil. 109. 1806.

V. filiformis Cav. Praelect. Bot. 270, 671. 1801; Willd. Sp. Pl. **5**: 405. 1801.

V. angustifrons Michx. Flor. Bor. Am. **2**: 261. 1803; *non* Bory. Itin. **2**: 325. 1804.

V. Schkuhrii Raddi, Fil. Bras. 51. 1819.

Taeniopsis lineata J. Smith, Hook. Journ. Bot. **4**: 67. 1842.

V. lineata Sw. Fée, Mem. Fam. Foug. **3**: 17. 1851; Hook. Sp. Fil. **5**: 180. 1864; Hook. & Baker, Syn. Fil. 396. 1874; in part; Eaton, Ferns of N. Am. **1**: 289. 1879; Sodiro, Crypt. Vasc.

* This synopsis is necessarily incomplete, owing to deficiencies in the descriptions, and lack of knowledge of the types.

Quit. 420. 1893; Jenman, Bull. Bot. Dept. Jamaica, 4: 251. 1897.

V. curvidentata CM.? Bot. Zeitung, 12: 546. 1854.

Linnaeus founded this species on the plate and description given by Plumier, cited Santo Domingo for the type locality, and adopted the specific name from Petiver's description, according to citations. Plumier figured the species very clearly on a large quarto plate, and described it in French and Latin; as this work is rare in America, it seems desirable to quote his description.

PLANCHE CXLIII.

"Langue de Cerf à feuilles tres longues et tres étroites. La racine de cette Langue de Cerf n'est proprement qu'un amas de plusieurs pédicules pourris mélez de plusieurs petites fibres roussatres, & toutes couvertes de mousses: elle jette quantité de feuilles tres longues & tres étroites, car elles n'ont pas plus d'une ligne & demie de large, sur environ trois pieds de longueur: elles sont fort pointuës, solides, épaisses comme du parchemin, unies, & d'un vert assez gay par devant, mais toutes traversées de biais en derriére par quantité de petites nervûres tres proches les unes des autres: outre ce elles ont aussi le bord replié en dedans, & couvrent tout le long de leur pli un nombre infini de tres petites vessies noiratres.

J'ay rencontré cette Plante en plusieurs endroits des Isles de l'Amérique, particuliérement à la Source de la Riviére Froide, vers le quartier du Port de Paix, dans l'Isle Saint Domingue."

Plumier's description agrees very well with the general acceptance of the characters of the species. It must be taken as the type of the genus, for J. E. Smith founded the genus on *Vittaria lineata;* there is no reason for taking up *Taeniopsis* of J. Smith, nor for citing Swartz as the authority for the species. It has been found that the sporophyte only has been described, and in the case of some of the synonyms, in the briefest and most superficial manner, giving only macroscopic characters. It follows that further study may reinstate some of these as species. This may be true of *V. filiformis* Cav. "foliis filiformibus, tripedalibus, glaucis." Fructification as in *V. lineata;* habitat Peru, or of *V. angustifrons* Michx. "frondibus simplicibus, integerrimis angus-

tissime longissimeque linearibus, debilibus. Fructification linea continua sub replicato frondis margine, ab istius sinu distincta. Hab. in Florida juxta ammem Aisa-hatcha."

It is not likely that the Florida species will be found to be distinct from the West Indian, but until the gametophyte of both is known there is still this possibility. Fée has suggested it in his memoir, as he states that he has seen in Willdenow's herbarium a specimen of *V. lineata* collected in Jamaica by Swartz, which had bright amber-colored sporangiasters, with the terminal cell mastoid or elongated pyriform, and that he also had a specimen collected in Florida from Richard which has ribbon-like sporangiasters. He believed the two plants were distinct species. Yet he contradicts himself in his description of *V. lineata* which he attributes to Swartz and states that the sporangiasters are vittate, with dilated colored contorted apex. He also states, that although *V. lineata* is the oldest species, there exists the greatest vagueness and uncertainty in the descriptions and that he considers it to be exclusively American. Unfortunately, he did not figure *V. lineata*, only the variety *graminifolia* Kaulf, without stating whether he had seen the types. He also took up *Taeniopsis*, as a subgenus, and referred *V. lineata* to it; we have shown that this position is untenable. In this he was followed by the authors of the Synopsis Filicum, who also reduced *V. filifolia* and several Asiatic species to *V. lineata*. We have already shown in the key, that *V. filifolia* has the characters of a good species, but we have not studied the exotic species.

There is another character of *V. lineata* which has been overlooked, probably because only mature, fruiting specimens are generally collected. This is the first leaf stages of the plant, which are quite distinct in size and shape, as may be seen by the plate. Jenman has described similar leaves in *V. intramarginalis*, of which he says: "A small plant which much resembles seedlings of *V. lineata* from which it is readily distinguished by the distinct small barren fronds (not however present in full-grown plants)." *

As none of the descriptions have been found to be complete, we have framed one from fresh material, and have necessarily been obliged to limit it to Florida specimens.

* Bull. Bot. Dept. Jam. 4: 213. 1897.

Gametophyte capable of indefinite growth and duration, branching irregularly or bifurcating into numerous lobes, which are proliferous by gemmae borne from podetia, usually on marginal cells; serving to propagate the plant asexually, and also rendering it autoicous by bearing antheridia; archegonia borne on the under side of the thallus.

Sporophyte forming rudimentary leaves, 1–4 cm. long, spathulate, with a single central vein ending below the apex or forming a loop in the rounded apex; rhizome short, divided, creeping, sparingly, densely covered with lanceolate, serrate, filiform-pointed scales, with papillose walled cells; leaves dark green or glaucous, two-ranked, crowded in dense compact pendent tufts, often 2–3 ft. long, 2–3 mm. wide, coriaceous, three-veined, the midvein pinnate and anastomosing with the lateral veins, with a deep sporangial groove over each lateral vein, in which the stomata are borne, paraphyses branching twice, usually forking, cylindric, the end cells curved and larger, brown; spores reniform, smooth, .027 × .054 mm.

Florida, as far north as St. Augustine; also credited to South Carolina by Fée and Hooker, but probably by mistake. Presumably the same as the West Indian species, of which the gametophyte is still undescribed, and the microscopic structure imperfectly known.

GAMETOPHYTE *

PROTHALLIUM.—(*F. 1–38*). The gametophyte of *Vittaria lineata* is an irregularly branched prothallium (*f. 1–4*), consisting of a single layer of distended cells containing chlorophyl (*f. 14, 15*). New prothallia may arise from any one of the marginal cells, or from two or more of the lamellar cells of the prothallium (*f. 5–8*). This capacity for vegetative reproduction by proliferation of the prothallus must be of great service to this species which is epiphytic on trees and much subject to the attack of small animals. Almost any fragment of the prothallus might continue growth independently.

The younger portions of the prothallia assume a horizontal position at right angles to the trunk of the tree to which they are attached, extending to a distance of 9 mm. in some instances. As the formation and growth of rhizoids proceeds successively in

* The material on which the anatomical study is based was collected by Miss Abbie M. Small at St. Augustine, Florida, 22 Feb. 1901, on the bark of the palmetto.

these younger regions, however, the rhizoids penetrate the bark of the tree and then draw the prothallus down against it. The rhizoids may be formed in clusters (*f. 1*) from an undifferentiated cell of the prothallus, or from a proliferation consisting of a single cell. Rarely more than one rhizoid originates from a single cell. The rhizoids are long colorless structures rarely branching near the apex, and sometimes distended at the base (*f. 13*).

The prothallium is occasionally monoicous-autoicous, but more frequently pseudo-dioicous with the antheridia and archegonia produced indirectly from the same plant. In such instances the archegonia are borne on the main prothallium, which also produces gemmae from which antheridia originate.

Barrel-form or spherical sterigmata containing chlorophyl arise from the margin, apex and occasionally from the middle of the prothallus bearing gemmae in great numbers. A sterigma may give rise to one or several gemmae, and these gemmae may divide repeatedly before falling off. The gemmae may either lie on the surface of the prothallus or stand out from it after the manner described by Goebel, who found the first position assumed in *Vittaria elongata* and the second in *Monogramma paradoxa* (*f. 19–25*).* A sterigma may give rise to several sterigmata before the gemmae are produced (*f. 22*). The gemmae are very similar to those of *Vittaria elongata* as described by Goebel and are in the form of spindles composed of 5 to 11 moniliform cells (*f. 28, 29*). The terminal cells may give rise to rhizoids, but these and the antheridia may be produced from any one of the cells of the spindle (*f. 30–33*). The gemmae produce prothallia in various ways, and also may develop other gemmae, and antheridia (*f. 33–37*).

ANTHERIDIA.— The antheridia are produced either directly from one or more cells of the gemmae (*f. 39, 40*), or on the lower surface of the prothallium, the margin and occasionally on the upper surface. A prothallium sometimes bears both antheridia and archegonia (*f. 56*). The development of the antheridia is as follows: A cell in any one of the positions named sends out a protuberance containing chlorophyl which becomes club-shaped

* Goebel, K. Morphologische and Biologische Studien. Ann. Jard. Bot. Buienzorg, 7: 78–107. 1888.

and then cuts off the terminal portion by a partition wall, making two cells of unequal size, the lower being much larger (*f.* *40b*, *41*). The apical cell becomes almost spherical, and the next wall formed in it is funnel-shaped, connecting with the wall previously formed in such manner as to separate a central cell. A third wall is now formed in the apical portion of the peripheral cell cutting off a cap cell shaped like a watch glass (*f.* *43–45*). The antheridium now consists of four cells, a pedestal cell, a hemispherical central cell enclosed by a cylindrical peripheral cell, and crowned by a cap cell (*f.* *42*). Further division occurs in the peripheral cell in rare instances. The first division wall in the central cell is generally longitudinal, and the second one is at right angles to it, and this sequence is followed during the formation of an indefinite number of mother cells (*f.* *42*, *44*).

An antherozoid is produced in each mother cell. The connecting walls of the mother cells dissolve and the antheridia lie free in the antheridium (*f.* *48a*). When the antheridium is ripe the antherozoids are ejected by the swelling of the peripheral cell and of the upper contiguous portion of the pedicel (*f.* *49*) which is pushed up into the antheridial cavity; the cap cell is ruptured either at the center or at one side. When the antherozoids escape from the antheridium they are enclosed by a thin membrane, which is thrown off shortly after their liberation. The antherozoids uncoil with a whip-like motion, curling and uncurling very rapidly during a few seconds, the movements of the cilia increasing in rapidity. The action of the cilia propels the antherozoid at a comparatively great speed, and they remain active for some time (*f.* *50*).

Four antheridia were seen in the act of discharging the antherozoids: the latter escaped in rapid succession, although two or three came out together in some instances. It was not difficult to count the emerging antherozoids, and two antheridia were found to contain twelve and another twenty-four. One antheridium was emptied in a little more than a minute, and the antherozoids burst the enclosing membrane in forty seconds or less after emergence. The entire number (twelve) had freed themselves in this manner in less than two minutes from the time action began. A portion of the mother cell in the form of a hyaline sphere with a granulated

center was carried by the antherozoids to which it was still attached forty-five minutes later.

Archegonia (*f. 57–60*).—The few archegonia that were seen occupied positions similar to those of *Vittaria elongata* as described by Goebel, being borne on the under surface of the prothallium, and also on the small lobes among the rhizoids. The archegonia have a slightly curved neck, although the number of cells shown on the concave and convex surfaces are the same, being four or five in number.

THE SPOROPHYTE

The sporophyte generally remains attached to the gametophyte for some time after its formation (*f. 89–91*).

RHIZOME.—The main axis of the sporophyte consists of a dorsiventral rhizome with short internodes bearing the tufted leaves in two ranks, the roots are very numerous and completely clothe the lower surface of the rhizome. The growing portion of the rhizome appears as a fleshy green bulbous formation with a conical apex, completely enveloped in long brownish scales (*f. 58, 59*). Glands, similar to those of the leaves and hairs, resembling those of the root are also present. The apical cell is wedge-shaped and the differentiation of the tissues follows quite closely the advance of the apical meristem (*f. 61, 62*).

In the earlier stages of development of the stelar tissues they appear as a cylinder of thin-walled elements (*f. 63*) in which the scattered groups of protoxylem soon appear (*f. 64d*). The metaxylem next appears as a complete cylinder of scalariform tracheids (*f. 65*). The metaphloëm is much more highly developed externally to the cylinder and consists of numbers of sieve cells separated from the metaphloëm and from the pericycle by parenchymatous elements. The pericycle is well defined (*f. 65a*). As the cylinder is traced upward along the stem, gaps appear where an entire segment of the fibrovascular ring is sent out into a leaf (*f. 66*). The external cortex, which is composed of extremely thin-walled elements in the younger specimens, becomes somewhat thickened and perforated in older organs. The epidermis does not participate in the thickening however.

ROOTS.—Roots are produced in great numbers from the rhizomes opposite the leaves and are usually quite advanced in devel-

opment as soon as visible. Hairs are produced profusely, originating .5 mm. from the tip. The roots quickly penetrate the bark of the palmetto tree to which the plant is attached, and as they are exposed to the light in various places form chlorophyl.

The root hairs measure from 0.6–4.5 mm. in length and .0115 .0299 in width. The hairs seldom form cross walls but occasionally branch near the apex, although the branches do not attain any considerable length. The roots branch profusely: one 13 mm. long produced 6 branches and 1 branch 7 mm. long produced 3 branches (*f. 88*). The central cylinder of the root is apparently diarchic (*f. 86, 87*) and the endodermis is plainly differentiated. The cortex consists of 4–6 layers of large cells with strongly differentiated walls; the outer rows show this striation less plainly however. The outer layer immediately internal to the epidermis contains large numbers of crystalline bodies connected with their inner walls (*f. 87, 88*). The epidermal cells are large, the thin outer walls being pressed inwardly in many instances.

STERILE LEAVES. — The leaves of *Vittaria lineata* show progressive variation in form and venation (*f. 89–95*). Those which arise earliest are spatulate and have a single central vein, later they show a branching venation (*f. 89, 93*). The laminar portion of the first leaves is flattened and the cross section does not show such complete dorsiventral differentiation as may be found in the leaves arising later. They are but slightly curved when they emerge from the scales, and the curvature soon disappears. The epidermal cells are somewhat longer than broad with wavy walls (*f. 97*). Among these cells are a few elements with pointed ends and wavy walls (*f. 98a*), which are most abundant near the fibrovascular bundles. The epidermal cells generally contain chlorophyl with the exception of the hyaline border. The latter is composed of elongated elements with oblique end walls (*f. 96a*). The epidermal cells of the petioles are prosenchymatous and rarely have wavy walls. Stomata occur on the under side of the lamina but do not occur immediately external to the veins. Numbers of club-shaped bodies, composed of three cells (*f. 97a*), resembling glands, are to be found on both surfaces. Scales arise on the basal portion of the earlier leaves di-

rectly external to the bundles, while these formations occur more abundantly on leaves developing later yet they are rarely over a bundle (*f.* 99).

Leaves formed from the rhizome at a later stage of growth show a variation in form from oblanceolate to linear (*f.* 94, 95). Such leaves have a vein extending through the middle and one along each margin with numerous anastomosing branches. Glands and scales are somewhat more numerous and the epidermis contains but little chlorophyl.

The latest leaves formed show the greatest length and are ridged over the nerves on the upper surface, bearing scales between the central and marginal veins (*f.* 109). These scales, while no more numerous on the upper surface than on the lower, are frequently larger, measuring as much as 1.9 mm. in length. It is found that the regularity of arrangement of the stomata and the increase of the ridges of the leaves increases as a form approximate to that of the adult is reached (*f.* 104).

SPOROPHYLLS. — The sporophylls are long linear coriaceous leaves with a short petiole exhibiting the epinastic growth of so many ferns. The numerous scales which doubtless serve as a protection to the unrolling leaves persist in mature forms (*f.* 109–111). The dorsal surface is marked by two deep grooves immediately external to the lateral veins, and these grooves contain the stomata, glands, sporangia and accompanying paraphyses (*f.* 104–109). The two fascicles of stelar elements given off from the edges of the incomplete cylinder in the foliar gap in the rhizome do not fuse until some distance in the petiole has been traversed, and the lateral branches are given off before the fusion is complete (*f.* 102, 103, 1, 6, 7). The lateral veins and the central vein are connected by various anastomosing branches (*f.* 102–106). The central vein runs quite to the apex of the leaf (*f.* 94–95), while the lateral veins end free a short distance below the tip or terminate in an anastomosing branch (*f.* 103–109). The vascular elements of the leaves are the same as the rhizome in composition, and the bundles are enclosed in a sheath of two to six layers of cells with perforated walls (*f.* 108*d*, *f*). The mesophyll of the upper side of the leaf is closely packed and contains a large amount of chlorophyl, giving this surface a dark green color (*f.* 114). The

mesophyll of the lower side is more loosely arranged and contains less chlorophyll (*f. 116*).

The epidermis is composed of elements with very thick walls except in the grooves (*f. 114–119*). A reduction in size is noticeable over the middle and lateral veins and at the margins of the leaves. Chlorophyl is to be found in the epidermal cells in the grooves but seldom elsewhere. The epidermis of the grooves is uniformly thin-walled and gives rise to stomata and glands; the latter are also found over the entire surface of the sporophyll. A narrow band of two to six rows of cells immediately external to the bundle underlying the groove bears the sporangia and paraphyses (*f. 123e*). One to four layers of prosenchymatous cells are to be seen underneath the epidermis of the upper side of the leaf (*f. 114b*). Similar elements are to be found on the lower side of the leaf between the grooves, and these cells are somewhat larger than those of the upper surface (*f. 116b*). These hypodermal prosenchymatous elements are generally free from chlorophyl and are separated by numerous large air-spaces, giving the region a light gray color. The absence of these elements in some instances cannot be accounted for.

SCALES. — Scales are most abundant on rhizomes and least so on the leaves produced earliest (*f. 72–74*). The first leaf formed may bear but one scale while the later leaves may be covered with them. The scales are never more than one cell in thickness and nine or ten in width, attaining a length of 5 mm. and a breadth of .4–1.1 mm. The growth of these structures is long-continued and the basal cells may be in a state of division while the apical portion may be withered and brown (*f. 75–82*). The thin walls of the younger cells at the base measure 1.9 μ in thickness which later increases to as much as 19.2 μ, which is a most noticeable multiplication. This thickening is confined to the cross walls, the outer walls not participating in this increase (*f. 76a, 81, 82a*). The thickened walls show great numbers of dots or minute papillae, which are most numerous in scales borne on the stems and are not easily found in scales of the earlier leaves. Both the thickening of the walls and the formation of papillae are less marked in the marginal region of the scales.

STOMATA. — Stomata are present only in the grooves of the

leaves. In the formation of these organs the upper portion of an epidermal cell is cut off by a wall having a horse-shoe shape in surface view (*f. 124b*). The newly formed cell appears to contain chlorophyl and the nucleus increases in size while the protoplasm becomes granular (*f. 125c*). This mother cell divides along a line parallel to the long axis of the epidermal cell from which it arose (*f. 126e*). The later stages of the splitting of the wall and the development of the guard cells follows in the usual manner (*f. 127*). The original epidermal cell from which the stomatal mother cell was cut off undergoes some alterations and it is difficult to distinguish it from its neighbors (*f. 121, 122*).

GLANDS. — The glands are club-shaped, measuring about .08 mm. in length and consist of three cells. These organs originate from the upper or apical end of the epidermal cells on both surfaces of the leaves and are inclined toward the apex of the leaf. The cross walls become suberized in a few cases and turn a rich golden brown (*f. 97, 110, 112, 128*).

SPORANGIA. — The sporangia and the attendant paraphyses are borne on the epidermal cells in the bottom of the two grooves on the under sides of the sporophyll (*f. 123, 129*). The margin of the leaf and the walls of the groove fold over and cover the sporangia and form a false indusium. An examination of any single sporophyll will show the presence of sporangia in all stages of development and these bodies are produced in such great profusion that many are not brought to full development. The principal features in the development of the sporangia are as follows: An epidermal cell sends out a tubular extension in which a wall soon appears parallel with the outer wall of the epidermis (*f. 130, 131, 136*) and a second wall cuts off a portion of the tube which becomes the sporangial stalk. Occasionally two or more transverse walls are formed in the basal portion of the structure before the terminal portion constituting the sporangial mother cell begins to divide (*f. 130*). Longitudinal divisions in the basal portion take place later. The sporangial mother cell first divides obliquely (*f. 130, 133b*) and then a second wall is formed at right angles to this (*f. 130, 134c*). A third and fourth division takes place resulting in the final formation of four outer cells which will constitute the wall of the sporangium

and a fifth central tetrahedral spore mother cell (*f. 130, 136d*). The cells which are to form the annulus divide by parallel walls into 13–15 cells (*f. 131*) which extend from the stalk at the base of the sporangium over the back a short distance down the other side, where they join with the thin-walled cells which connect with the lip cells (*f. 133b*). When the sporangium is young, these cells have thin walls and become inflated and raised above the other cells (*f. 133a*). These cells contain chlorophyl which is often retained until the spores are fully formed.

As the sporangium ripens, the walls of the annulus thicken considerably with the exception of the dorsal wall, becoming cuticularized (*f. 134a*) and take on a golden brown color which later turns to a dull brown. The dorsal walls turn a dull yellow, and frequently bend back toward the inner walls of the cells, so that the cross walls form ridges along the annulus of the old sporangium. The other cells of the sporangium also divide. The frontal cells are generally eight in number and extend from the annulus to the pedicel at the base of the sporangium. They are composed of two kinds of cells, those whose walls do not thicken to any extent—called connective cells—and those whose walls thicken considerably forming the lips. There are four lip cells and they occupy the center of the row of seven or eight, occasionally nine (*f. 133c, 134c*). These lip cells differ greatly from the other cells of the sporangium, having a short longitudinal diameter and a very long radial one. They are connected with the annulus by one to three thinner walled cells, and with the pedicel by two (*f. 133bb, 134bb*). The two lip cells, which occupy the center of the group of four, frequently thicken their walls to a greater extent than the other two, and it is between these two cells that the sporangium opens when the spores are ripe (*f. 134*), the slit extending back generally in a straight line through the thin walls of the other cells almost to the annulus. The central tetrahedral cell of the sporangium divides by oblique walls until another tetrahedral cell has been formed inside of it (*f. 130 9f*), this inner cell dividing up into the spore mother cells and the cells between this cell and those constituting the sporangial wall form the tapetal cells (*f. 130, 9g*), which dissolve after a time so that the spore mother cells

lie free in the sporangium. Each mother cell divides into four spores. These ripe spores are reniform with a smooth surface.

PEDICEL.—The pedicel is long and consists of three or more cells, though only one cell wide until near the sporangium, where the first longitudinal walls are formed (*f.* 139, 9, 133*e*, 134*e*, 135, 1, 2); here it is generally two cells in width, less often three, though at the base of the sporangium there are almost always three cells. These small cells are formed at or near the front of the sporangium (*f.* 133, 134). As the sporangium ripens all the cells of the upper part of the pedicel become inflated and throw the sporangium back (*f.* 134), so that when the split occurs, and the lip cells open by the everting of the annulus, the spores have a less interrupted access to the opening of the groove, their original position being such that did they keep it during the discharge of the spores many of them would become entangled among the branches of paraphyses from which they would be powerless to escape.

PARAPHYSES. — The paraphyses develop before and with the sporangia and frequently attain a large size while the sporangia are still very immature. They are always multicellular and branched, except when young (*f.* 129); they grow to some length as a single cell before they branch into two or three divisions (*f.* 129, 136–139), the first cell of each forming a stalk. The round branches generally branch in their turn. The cells are two or three times longer than wide, each containing a good-sized nucleus and some chlorophyl; as they grow older they become discolored and shrivel up. The branches terminate in cells which are always very long, much wider at their apex and generally curved (*f.* 136, 137).

SUMMARY

The gametophyte of *Vittaria lineata* is an irregularly branched, pseudo-dioicous prothallium, bearing the archegonia and giving rise to gemmae which bear the antheridia and also produce new prothallia.

The *antheridia* are produced in great numbers, rarely on the same prothallium with the archegonia. From twelve to twenty-four antherozoids are produced in one antheridium and the opening occurs in the center of the cap cell, or at its junction with the

peripheral cells. It ruptures by the swelling of the peripheral cell or cells, and the portion of the pedicel immediately under the antheridium; this drives the wall that separates them up into the antheridial cavity, and ejects the antherozoids.

The *archegonia* occur among the rhizoids near the margin, on the under side of the older portions of the prothallium; also on specialized branches which are formed at the margin of the main prothallium. They have slightly curved necks, but the rows of cells in both the anterior and posterior sides are equal in number.

The *rhizoids* are unicellular, simple or branched, structures and are produced either directly from a cell of the prothallium or by the formation of an initial cell.

The *sporophyte* consists of a creeping, dorsiventral rhizome, bearing its leaves ordinarily in two ranks. It frequently branches and the internodes of both stem and branch are so short that the leaves appear crowded together. The growing point appears as a fleshy green bulb which is densely covered by brown scales having a structure peculiar to this genus. The *rhizome* has a wedge-shaped apical cell and a concentric, tubular bundle, with foliar-gaps associated with the leaf-bundles.

The *roots* are produced near the growing tip and are usually twice as numerous as the leaves. They have a normal root-cap and an axial diarch bundle, the two groups of xylem are generally united after a time by large tracheids. The walls of the parenchymatous cells are strongly striated and in the young roots there are crystalline substances formed against the inner walls of the cells immediately under the epidermis. The roots branch frequently and the branching appears to bear a definite relation to the original xylem groups of the diarch bundle.

There are three kinds of *leaves;* first, the rudimentary ones which are spathulate and long-petioled, usually with a single central vein; second, the young sterile leaves, which are short-petioled, oblanceolate to linear, and show all gradations of venation, from the simple central vein to the three veins which characterize the sporophyll. The sporophylls are short-petioled and linear.

The *venation* of the leaf arises from two primary bundles, each giving rise to one smaller one which become the lateral bundles

of the leaf. The larger portion of the two primary bundles unite to form the central bundle; these three bundles run parallel with the long axis of the leaf and are united with each other at intervals by small strands taking an oblique apical course from the central one to each lateral one.

The *sporophyll* has two deep dorsal grooves, running parallel with the lateral bundles and just over them; in these grooves occur the stomata and glands, and in them are borne the sporangia and paraphyses. All the leaves bear scales which show a higher order of development as the leaves approach the type of the sporophyll.

The *sporangia* are long-stalked and spherical with an annulus of about fourteen cells, four lip cells and four connectives. The spores are reniform with a smooth outer coat. The smaller cells on the pedicel at the base of the sporangium become very much inflated and when the sporangium opens they tilt it back, thus aiding in the escape of the spores. The paraphyses are long-stalked, branched and multicellular; the terminal cells being longer, curved, and enlarged at the apex.

Explanation of Plates

The figures were drawn with a magnification twice that indicated and the resulting figures were reduced one half.

PLATE 23

FIG. 1. Under side of a prothallium, showing its irregular branching: *a*, rhizoids; *b*, sterigmata. × 7.

FIG. 2. A young prothallium showing sterigmata along margin. × 7.

FIG. 3. Prothallium showing manner of branching at apex. × 6.

FIG. 4. An older piece with the archegonia just forming. *a*, rhizoids; *b*, archegonia; *c*, sterigmata; *d*, young sporophyte. × 9.

FIG. 5. Margin of prothallium at apex, showing branching and *b*, sterigmata. × 25.

FIGS. 6, 7. Young prothallia starting from margin of old ones. × 120.

FIG. 8. A young prothallium, *a*, with three growing points starting from a single cell of an old prothallium. × 25.

FIG. 9. Four marginal cells of the prothallium, each one giving rise to a rhizoid. × 87.

FIG. 10. Same as Fig. 9. × 87.

FIG. 11. A rhizoid formed from an initial cell. × 87.

FIG. 12. A rhizoid formed from two cells. × 120.

FIG. 13. Rhizoid with inflated cell. × 87.

FIG. 14. Side view of portion of prothallium showing inflated cells; *a*, rhizoids; *b*, sterigmata with gemmae and also curved apex. × 25.

FIG. 15. Portion of prothallium with apex recurved; gemmae are shown at the margin. × 25.

FIG. 16. Apex of prothallium, *a*; *b*, sterigma and gemmae; *d*, filament growing from the margin; *e*, sterigmata; *f*, young prothallium with a sterigma and gemma; *g*, growing end of filament. × 87.

FIG. 17. A prothallium showing eleven growing points.

FIG. 18. A filament from a margin of a prothallium. × 45.

PLATE 24

FIGS. 19–22. Apex of prothallia showing sterigmata and gemmae. × 87.

FIG. 23. Marginal cell, sterigmata and gemmae. × 120.

FIGS. 24–26. Prothallia showing many-celled gemmae. × 25.

FIG. 27. Gemmae. × 87.

FIG. 28. Gemmae of six cells: cells *a*, *a* forming rhizoids. × 120.

FIG. 29. Same as Fig. 28, only older. × 87.

FIG. 30. A gemma of which one cell has sent out a filament of three cells and an antheridium. × 87.

FIGS. 31, 32. Gemmae with rhizoids. × 35.

FIG. 33. Gemma, with an antheridium, *a*, a rhizoid at each end and small aprothallium originating from two cells. × 45.

FIG. 34. Gemma, with rhizoids and prothallium. × 35.

FIG. 35. Gemma with a young prothallium originating from a single cell. × 87.

FIG. 36. A gemma with two withered antheridia, *a*, *a*, and a young prothallium, from the margin of which have arisen three prothallia. × 35.

FIG. 37. A gemma of five cells, bearing two rhizoids and two prothallia, the older one producing sterigmata and branching in two places. × 25.

FIG. 38. Portion of the apex of the parent prothallium with two filaments: one still growing and bearing an antheridium, *a*, and a rhizoid, *b*, and the other filament (broken) and bearing two rhizoids. × 35.

PLATE 25

FIG. 39. Gemma showing an antheridium, *a*, as a small protuberance from one of the cells; the next cell has given rise to a filament of two cells, *b*; *c*, *c*, rhizoids. × 87.

FIG. 40. Gemma with an antheridium, *a*, showing first wall, *b*; *c*, nuclei; *d*, chlorophyl. × 120. In places the gemma is more than one cell wide.

FIGS. 41–49. Stages in the development of the antheridia and antherozoids.

FIG. 41. *a*, Nuclei. × 210.

FIG. 42. *a*, Peripheral cell; *b*, cap cell; *c*, central cell dividing into the mother cells of the antherozoids. × 210.

FIGS. 43–45. Showing the different ways the walls may be formed, in tiers or obliquely; *a*, central cell. × 120.

FIGS. 46, 47. Looking down on the antheridium, showing the mother cells, *a*. × 210.

FIG. 48. A ripe antheridium with the mother cells, *a*, lying free, each one containing an antherozoid. × 210.

FIG. 49. An antheridium with two antherozoids still inside; *a*, ruptured cap cell; the antheridium also showing the inflated peripheral cell, and inflated upper portion of the pedicel. × 210.

FIG. 50. Three antherozoids, *a*; *b*, cilia; *c*, portion of mother cell. × 600.

FIGS. 51, 52. Two antheridia consisting of more than one peripheral cell. × 210.

FIG. 53. Gemma with three antheridia, one in the act of discharging the anther; ozoids; *a*, rhizoid. × 88.

FIGS. 54, 55. Gemmae with antheridia, *a*, and rhizoids, *b*. × 120.

FIG. 56. An antheridium from near margin of parent prothallium; *a*, antheridium; *b*, pedicel. × 210.

FIG. 57. Under side of wing of prothallium showing archegonia, *a*, *b*, the four stigmatic cells. × 87.

FIG. 58. A prothallium with young sporophyte; *a*, prothallium; *b*, archegonia; *c*-first leaf of young plant; *d*, root; *e*, root hairs; *f*, foot, *g*, scales around the growing tip of rhizome and next leaf. × 7.

FIG. 59. Wing of a prothallium with three young archegonia, *a*, and sporophyte, *b*. × 5.

FIG. 60. *a* of Fig. 59 magnified 35 times, to show young archegonia, *b*; *c*, foot imbedded in the calyptra; *d*, rhizome; *e*, root.

PLATE 26

FIG. 61. Longitudinal section of rhizome near apex, *a*; *b*, young leaf; *c*, scales. × 12.

FIG. 62. A portion of the same showing the differentiating tissues: *a*, apical portion; *b*, epidermis; *c*, cortical parenchyma; *d*, vascular bundle; *e*, medullary parenchyma; *f*, young scales. × 120.

FIG. 63. Cross section of rhizome near tip, *a*, cortex; *b*, meristem of bundle; *c*, medullary parenchyma. × 120.

FIG. 64. The same further from tip, *a*, cortex; *b*, medullary parenchyma; *c*, phloëm; *d*, xylem, the walls of the tracheids thickening. × 120.

FIG. 65. Older portion of rhizome. Marking as in Fig. 64. × 120.

FIG. 66. Cross section of the tubular bundle, *a*; showing two root bundles, *b* and *c*; and the two bundles of a leaf, *d*, *d*; with a "foliar gap," *e*; *f*, medullary parenchyma; *g*, cortical parenchyma. × 45.

FIGS. 67–71. Diagrams showing the different aspects of the tubular bundle in cross section, *a*, leaf bundles; *b*, "foliar gap" of leaf above; *c*, root bundles. × 11.

FIGS. 72, 73. Outlines of scales. × 13.

FIG. 74. The same, magnified ten times to show the cells.

PLATE 27.

FIG. 75. Basal portion of scale showing the thin-walled cells. × 87.

FIG. 76. Cells from the margin half way up the scale showing the thin outer wall, *a*, and the papillae on the thickened inner walls, *b*. × 120.

FIG. 77. Portion of scale showing the framework of suberized walls, *a*. × 120

FIG. 78. The characteristic twist of the thin portion of the cross walls at margin. × 210.

FIG. 79. View of the back of the scale at base showing bend. × 25.

FIG. 80. Base of scale showing twist. × 25.

FIG. 81, 82. Apex of scales showing the wrinkling of the thin outer wall, *a*. × 87½.

FIG. 83. Longitudinal section through tip of root: *a*, root cap; *b*, apical portion; *c*, parenchymatous cells; *d*, meristem of axial bundle. × 45.

FIG. 84. Tip of root showing how the cap cells often curl before being thrown off — *a*; *b*, three cap cells still remaining attached to root.

FIG. 85. Portion of rhizome bundle showing connection of root bundle; *a*, endodermis; *b*, phloëm; *c*, xylem; *d*, cortex; *e*, medullary parenchyma. × 120.

FIG. 86. Diarch bundle of young root: *a*, cortex; *b*, endodermis; *c*, *c*, phloëm; *d*, *d*, two primary xylem groups. × 292.

FIG. 87. Cross section of young root: *a*, rhizoids; *b*, cells containing crystalline substances; *c*, endodermis; *d*, the two phloëm groups; *e*, xylem. × 38.

FIG. 88. Cross section through root and two of its branches, and a longitudinal section through a third branch at its point of attachment with the first root: 2 was given off first; then 3; and then 4. Marking as in Fig. 87. × 45.

PLATE 28

FIGS. 89, 90. Prothallia and young sporophytes growing on the bark of the palmetto. × 3.

FIG. 91. A wing *a*, of the prothallium showing young sporophyte; *b*, first leaf; *c*, root. × 9.

FIGS. 92, 93. Rudimentary primary leaves showing variation. × 2.

FIG. 94. Variation of secondary leaf.

FIG. 95. Mature sterile leaf, the sporophyll shows the same variation with the exception that the two primary veins, *b*, are apt to run a longer distance before anastomosing; 2 is basal portion of 1, they join at *a*; *b* primary veins. × 2.

FIG. 96. Apex of first leaf showing epidermis of under side of hyaline border. × 87½.

FIG. 97. Portion of epidermis of same under side: *a*, gland; *b*, stoma. × 210.

FIG. 98. Portion of epidermis showing prosenchymatic cell *a*. × 210.

FIG. 99. Scale from upper side of first leaf. × 87.

FIG. 100. Cross section of petiole showing vascular bundle with two xylem groups, *b*, in primary leaves. × 25.

PLATE 29

FIG. 101. Surface view of rhizome, with the leaves removed to show the two-ranked arrangement, and the two primary bundles. × 11.

FIG. 102. Diagram of leaf bundles: *a*, bundle of rhizome; *b*, the two primary bundles; *c*, first lateral bundle; *d*, second lateral bundle.

FIG. 103. Nine diagrams showing different cross sections of leaves with bundles. In 2, 3, 4 and 5 the thick-walled cells surrounding primary bundles have united before the formation of the lateral bundles, and shows the primary bundles anastomosing after the lateral bundles have been given off; 9 shows the apex of a leaf with one lateral bundle ending free.

FIG. 104. Diagram of middle portion of leaf: *a*, central bundle composed of parts of the two primary bundles; *b*, thick-walled cells surrounding bundle; *c*, mesophyll; *d*, band of thick-walled cells and epidermis; *e*, groove (under side of leaf); *f*, lateral bundle; *g*, denser mesophyll of upper side of leaf. × 13.

FIGS. 105, 106. Cross sections of petioles showing different degrees of thickening of the outer parenchymatous cells of the cortex. Fig. 105 is more often found in the sporophylls. 1, upper side; *a*, primary bundles. In Fig. 106 one lateral bundle is shown, *b*. × 25.

FIG. 107. Cross section of central bundle of leaf; *a*, phloëm; *b*, xylem; *c*, endodermis; *d*, thick-walled cells of the ground tissue surrounding bundle. × 120.

FIG. 108. Cross section of one of the lateral bundles. Marking as in Fig. 107. *e*, mesophyll of under side; *f*, thin-walled epidermal layer which gives rise to the sporangia. × 120.

FIG. 109. Curled apex of young sporophyll showing scales, *a*, and cut so as to show the bundles, *b*; and grooves, *c*. × 15.

FIG. 110. Side view of apex of young leaf showing curl and glands. × 13.

FIG. 111. Front view of same. × 13.

FIG. 112. Portion of epidermis from under side of young leaf; *a*, scale; *b*, gland; *c*, stoma just forming. × 87.

PLATE 30

FIG. 113. Apex of leaf. Dotted line indicates the area of the dense mesophyll cells, containing chlorophyll, under epidermis. × 87.

FIG. 114. Portion of upper side of leaf, over bundle, seen in cross section; *a*, epidermis; *b*, thick-walled cells, generally prosenchymatic, often becoming bast-like; *c*, mesophyll cells containing chlorophyl. × 87.

FIG. 115. Portion of epidermis, *a*, from under side of young frond showing first stoma, *d*. Marking as in Fig. 114.

FIG. 116. Ridge over bundle on under side. × 87.

FIG. 117. Inner margin of groove extending from ridge to ridge. Marking as in Fig. 114. × 87.

FIGS. 118, 119. Illustrate peculiar folding of the epidermal walls. Fig. 119 has been treated with potash to show the way they fit into each other.

FIG. 120. Diagram of surface of under side of leaf showing the ridge and lateral grooves, *a*, the stomata and glands. × 13.

FIG. 121. Epidermis from groove; *a*, stoma; *b*, gland. × 87.

FIG. 122. *A*, represents width of groove from edge to the sporangial layer; *b*, stoma; *c*, initial cell; *d*, original epidermal cell.

FIG. 123. Cross section of groove: *a*, stoma; *b*, epidermal cell; *c*, air space; *d*, thick-walled cells around bundle; *e*, thin-walled epidermal layer giving rise to the sporangia, *f*, and paraphyses, *g*. × 120.

FIGS. 124–126. Showing origin of the stoma: *a*, original epidermal cell; *b*, initial cell of the stoma; *c*, the mother cell of the stoma; *d*, longitudinal wall through mother cell, in Fig. 126, dividing it into the two guard cells, *e*, *e*; *f*, nucleus; *g*, chlorophyl. × 294.

FIG. 127. Mature stoma. Dotted line, *h*, represents wall of mother cell, the two guard cells being raised somewhat above the epidermis as in the cross section (Fig. 123). Marking as in Figs. 124–126. × 310.

FIG. 128. Gland. × 294.

PLATE 31

FIG. 129. A diagram of the longitudinal section of the leaf passing through center of groove: *a*, upper epidermis and band of thick-walled cells; *b*, mesophyll; *c*, *c*, band of thick-walled cells surrounding bundle; *d*, lateral bundle; *e*, thin-walled layer of epidermis giving rise to the sporangia; *f*, sporangia here shown in all stages of development; *g*, the paraphyses. × 25.

FIG. 130. Nine sections showing the development of the sporangium: *a*, original cell of the sporangium; *b*, first oblique wall; *c*, second wall; *d*, first tetrahedral cell; *e*, peripheral cell dividing to form the sporangial wall. No. 9 shows the divisions of the tetrahedral cell, which form the mother cells of the spores and the tapetal cells, *g*; *h*, pedicels. No. 5, surface view of very young sporangium. × 120.

FIG. 131. Nos. 1 and 2. Surface views of older sporangia: *a*, annulus; *b*, lip cells just forming; *c*, cells of pedicel at base of sporangium. × 120.

FIG. 132. Mother cells from a young sporangium before dividing to form the spores. × 210.

FIG. 133. Young sporangium, all the cells containing chlorophyl, except the lip cells; *a*, annulus; *b*, *b*, four connective cells; *c*, the four lip cells; *d*, thin-walled cells of sporangial wall; *e*, pedicel. × 120.

FIG. 134. Ripe sporangium showing the way in which it opens: *f*, spores. Marking as in Fig. 133. × 120.

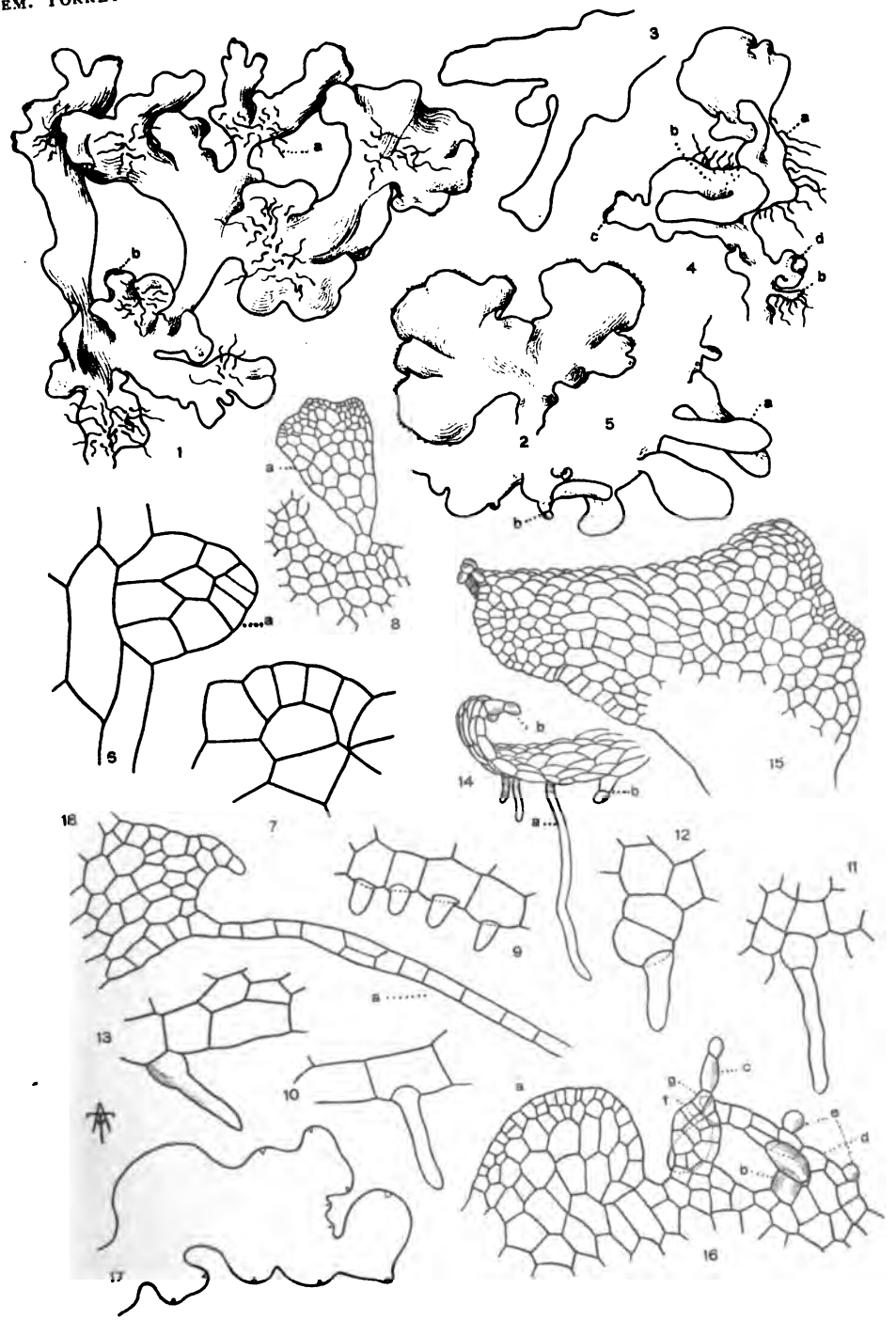
FIG. 135. Different ways in which cells of pedicel divide; part of the basal portion of the sporangium is shown at *a* in No. 1. No. 1, × 87. No. 2, × 120.

FIG. 136. Four cells from epidermal layer, *a*, one of which has given rise to a young sporangium, *b*; *c*, first tetrahedral cell in process of dividing (this stage is between Nos. 8 and 9 of Fig. 130); *d*, sporangial wall; *e*, pedicel; *f*, young paraphysis from adjoining cell containing a nucleus and some chlorophyl. × 120.

FIGS. 137, 138. Young paraphyses. × 120.

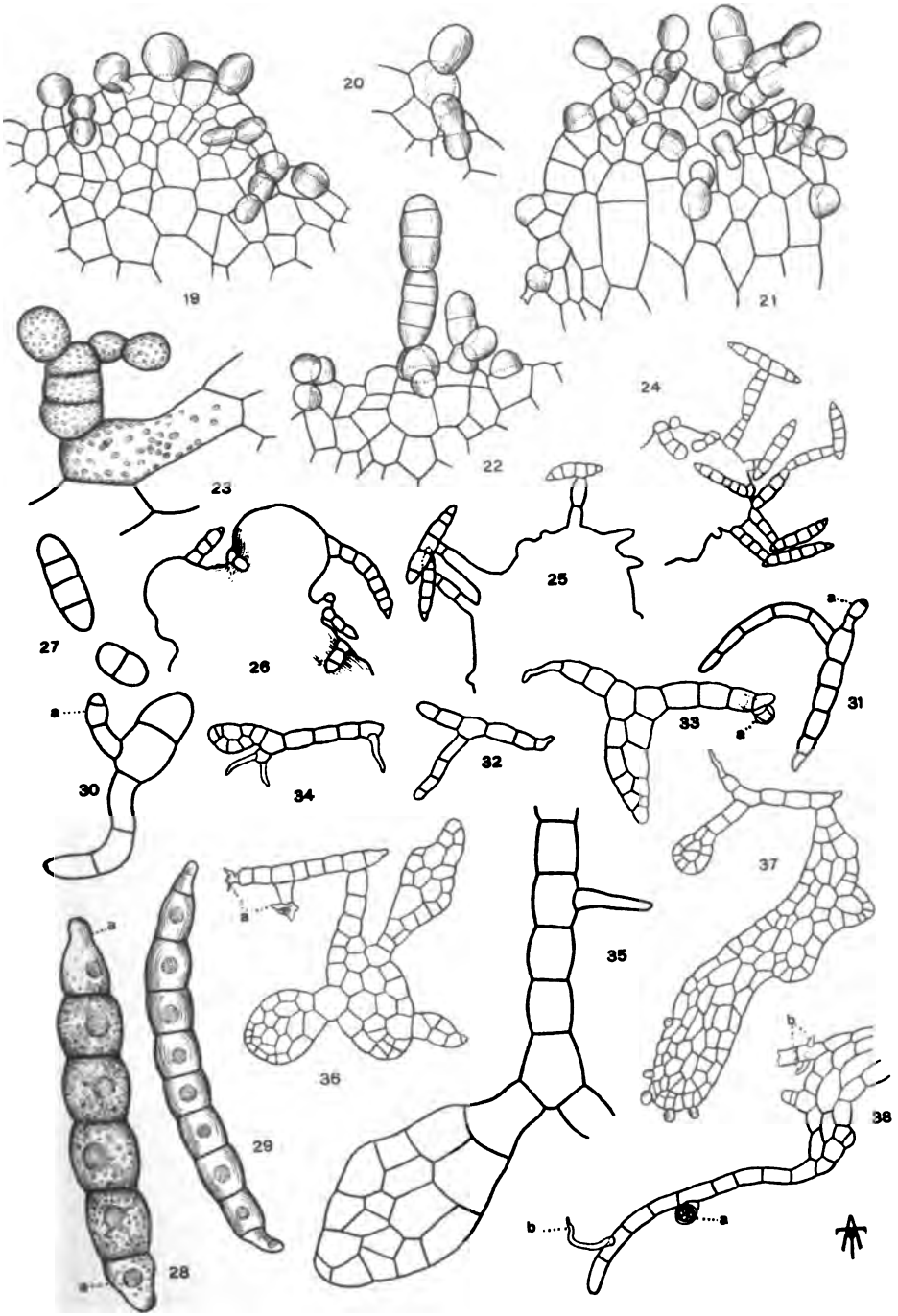
FIG. 139. Seven diagrams showing the branching of the paraphyses.

FIG. 140. Young sporophyte, *b*, growing from mutilated end of rhizome, the growing apex of rhizome having been removed; *a*, base of two old sporophytes.



VITTARIA LINEATA

HELIOTYPE CO., BOSTON



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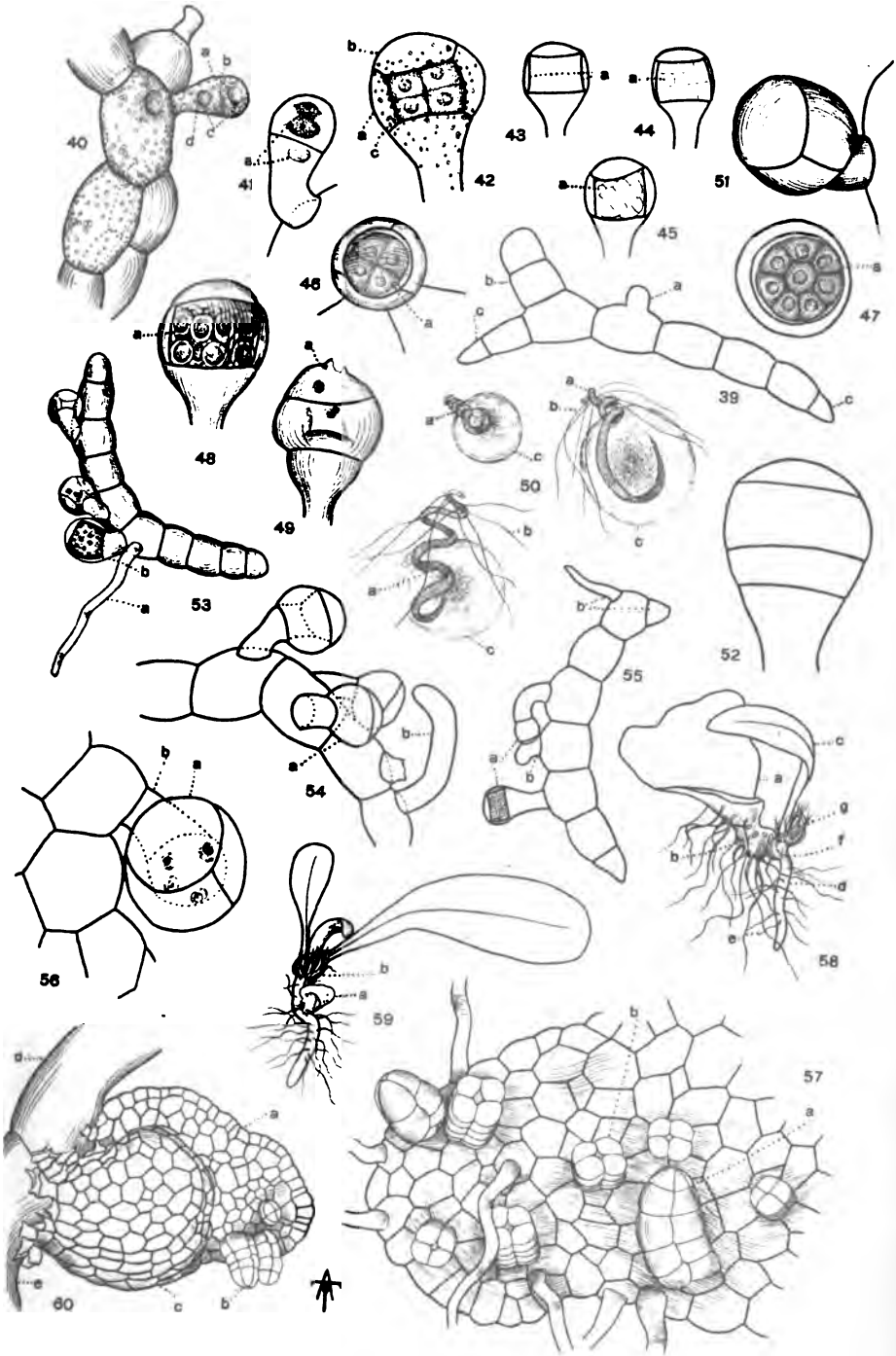

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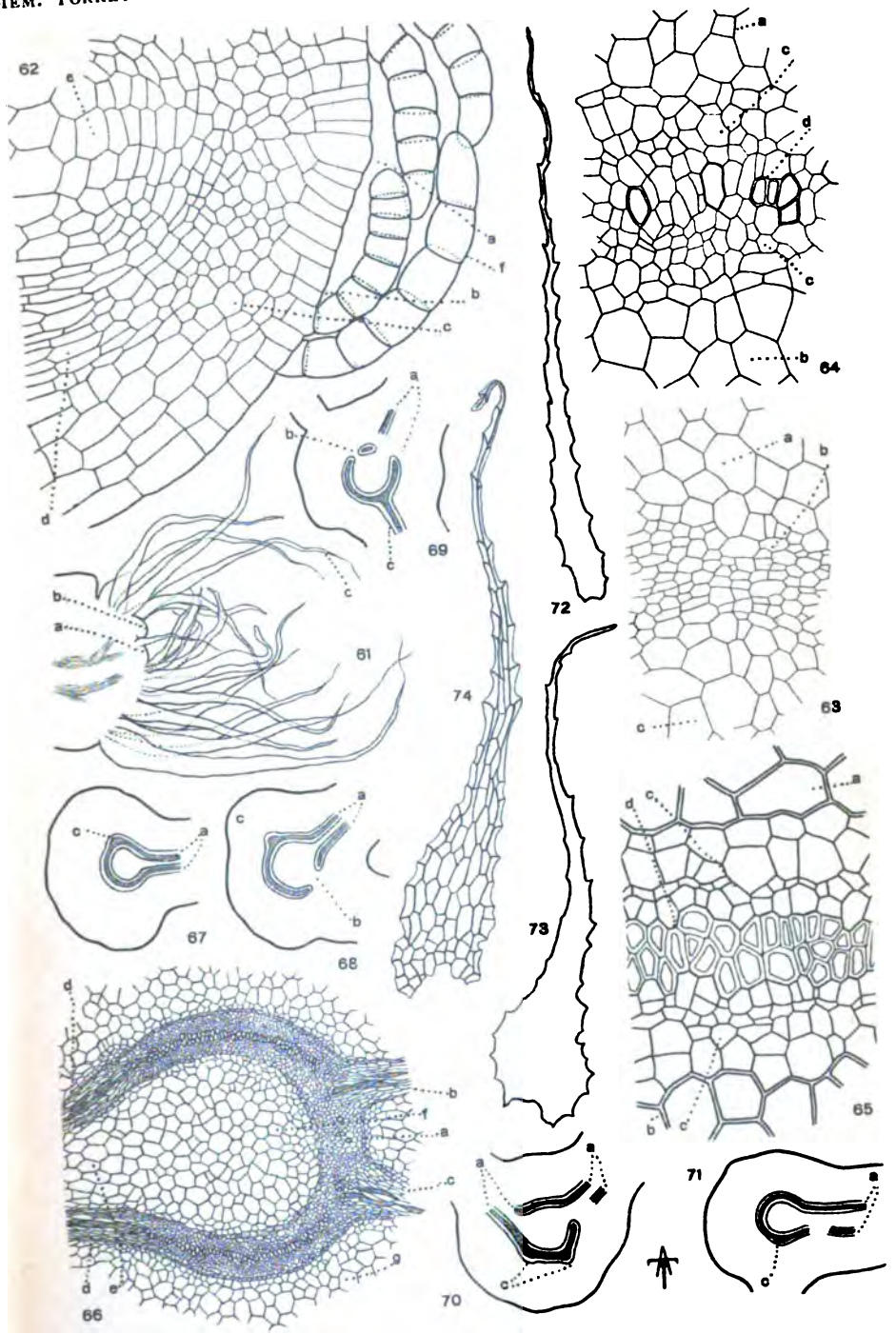

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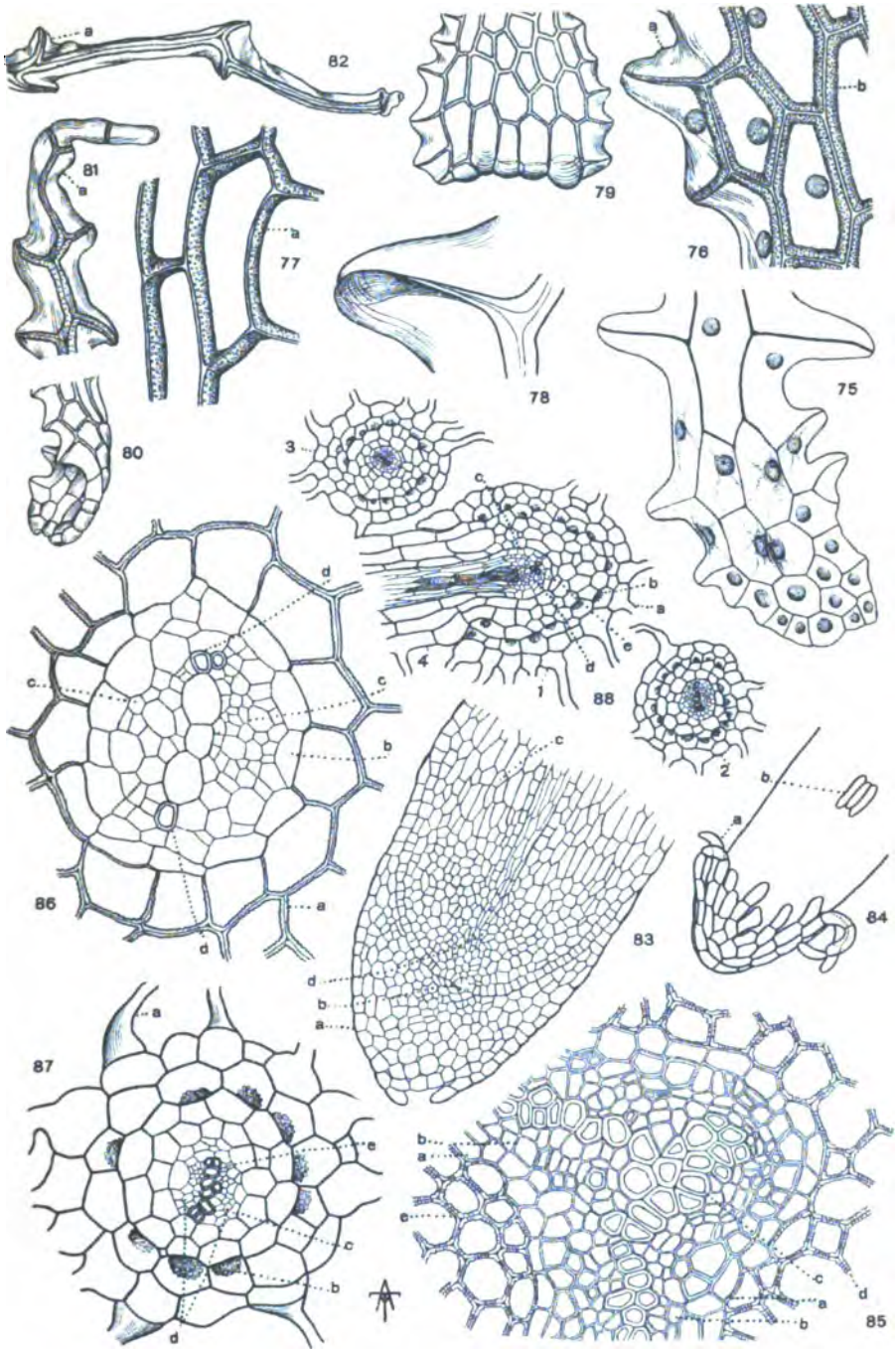

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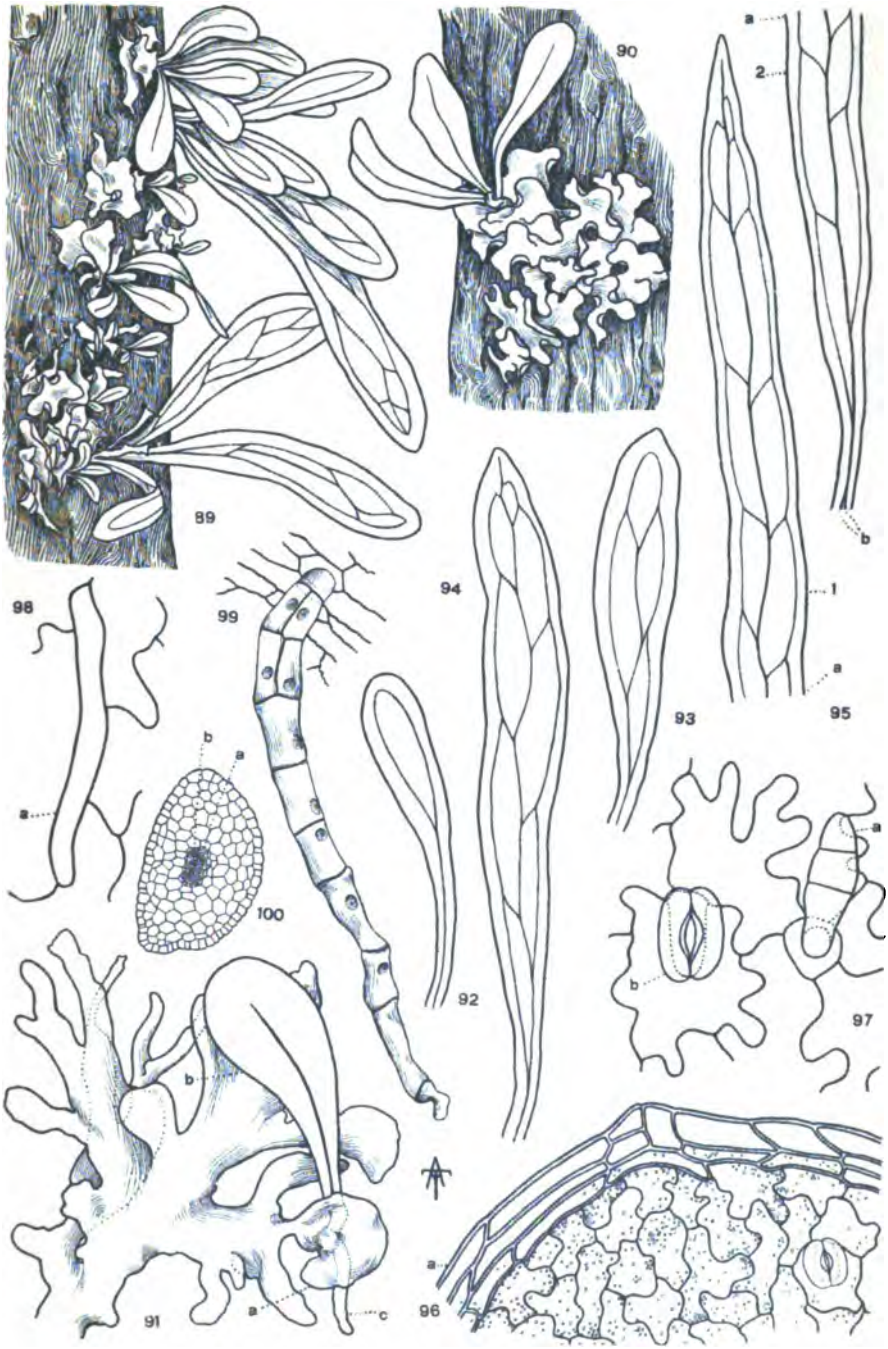

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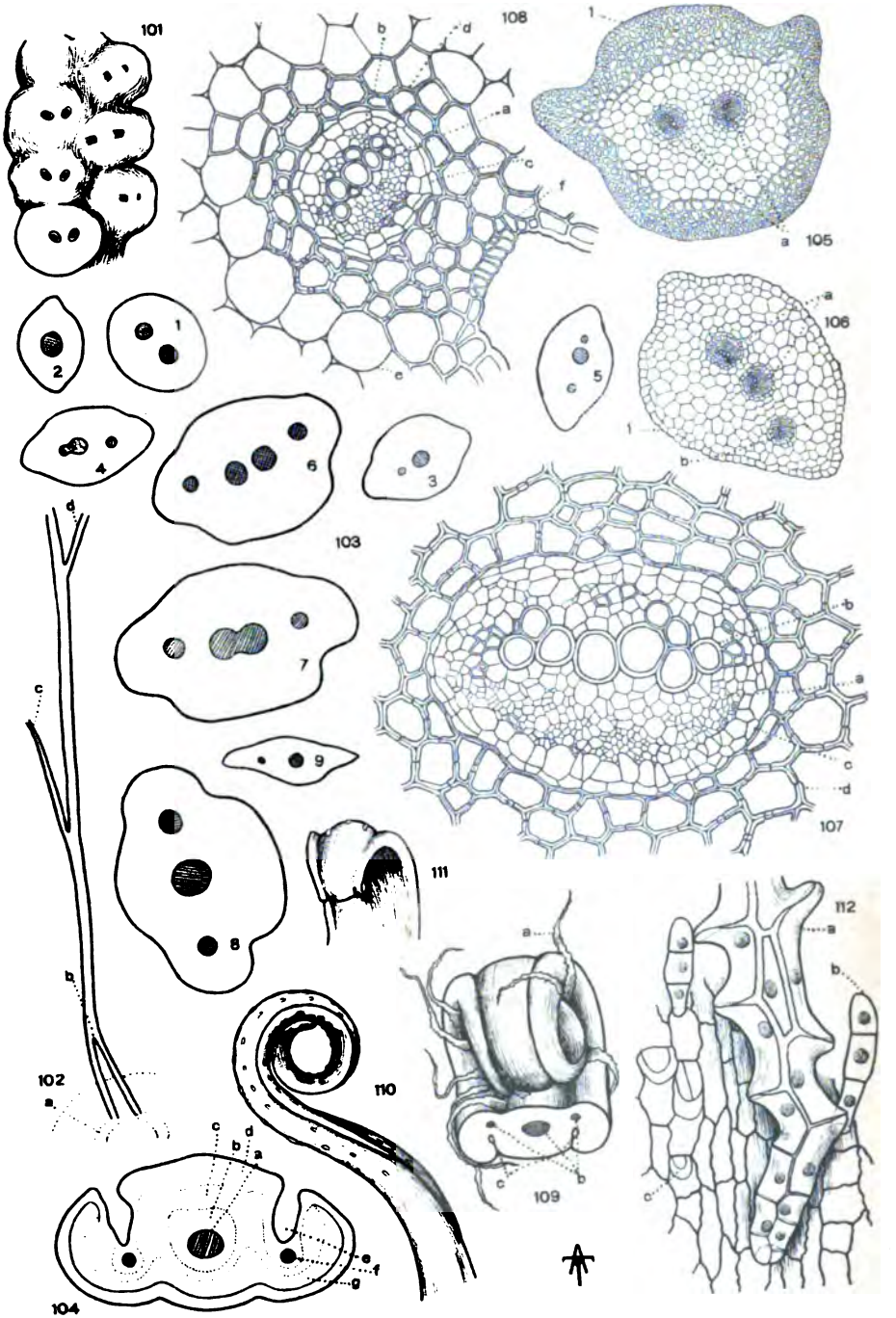

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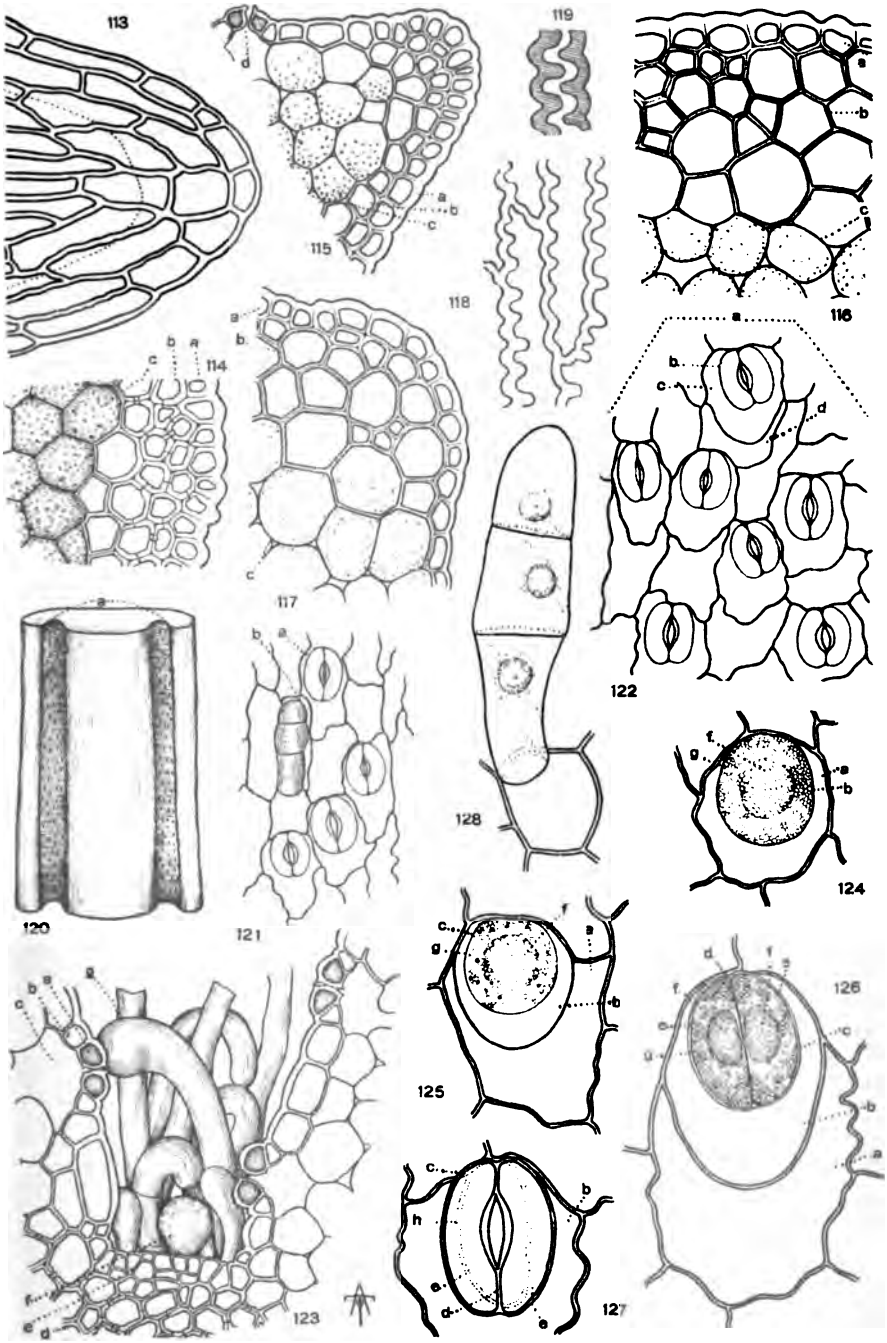

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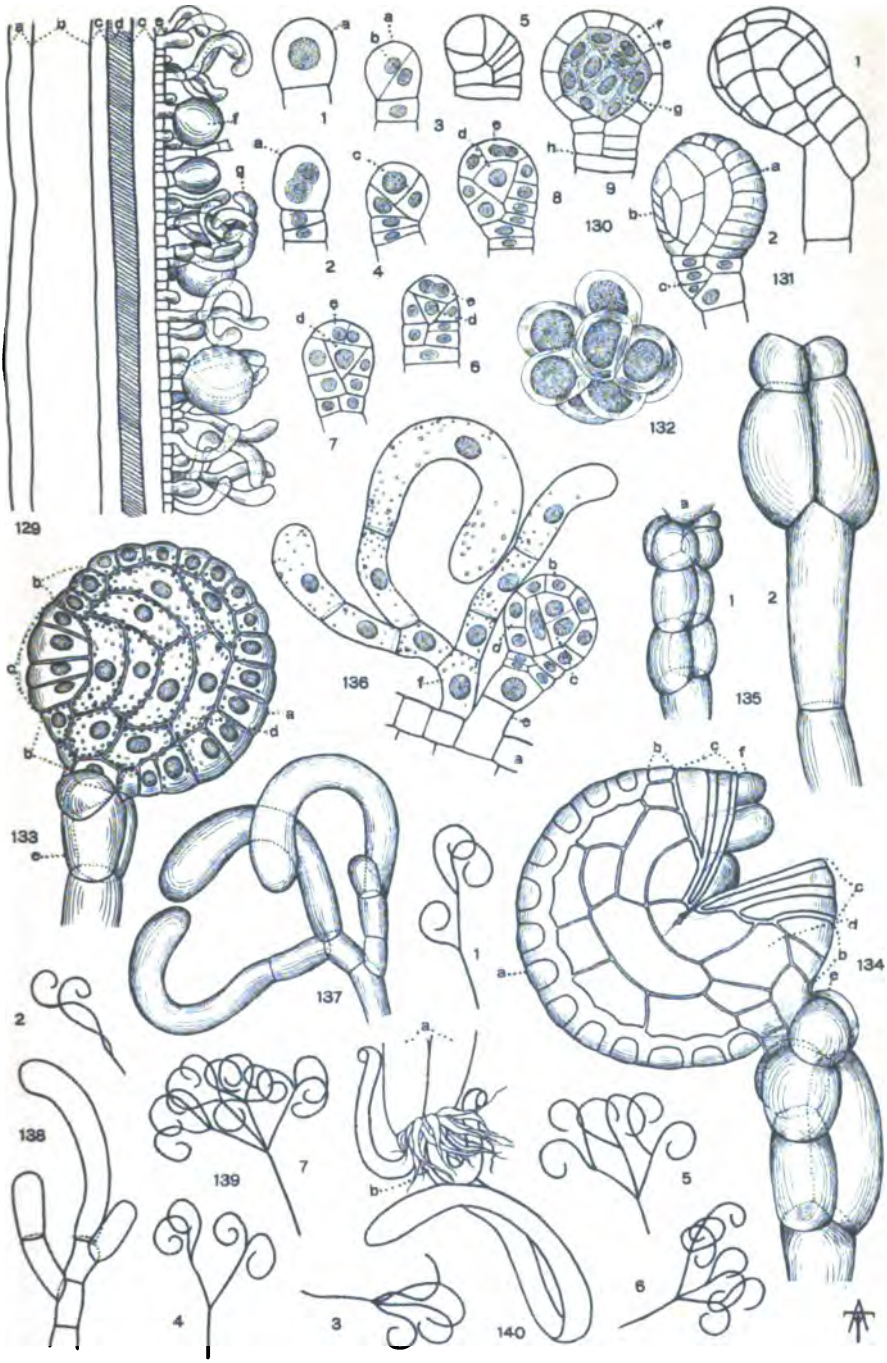

VITTARIA LINEATA

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MEMOIRS

OF THE

TORREY BOTANICAL CLUB

VOLUME IX

A MONOGRAPH

OF

THE ERYSIPHACEAE

BY

ERNEST S. SALMON, F.L.S.

NEW YORK
1900

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INTRODUCTION

The *Erysiphaceae* are popularly known in different countries as "White" or "Powdery Mildews," "Blight," Mehlthau, Blanc, Honungs-dagg, etc. Throughout the summer they are conspicuous in their "*Oidium*," or conidial stage on many common plants, *e. g.*, roses, hops, vines, peas, maples, *Plantago*, *Heracleum*, *Polygonum*, *Spiraea*, *Corylus*, *Quercus*, *Crataegus*, etc., and give to the infected parts of the host-plant a whitish mealy or dusty appearance due partly to the white web-like mycelium, and partly to the presence of myriads of rapidly-formed white conidia.

Later in the summer, and in autumn, the ascigerous form of fruit is produced in the shape of small, more or less globular, dark brown or black perithecia, usually provided with special outgrowths termed appendages. After producing these the mycelium often dies away, and the perithecia are left as small, blackish, globular bodies on the surface of the leaves and stems of the host-plant. Sometimes, however, the mycelium is thick and persistent, and the perithecia are then found more or less immersed in it.

The *Erysiphaceae* are characterized by the truly parasitic habit, the white mycelium, the production of large, colorless (or white) non-septate conidia on simple, erect conidiophores (forming the *Oidium* stage), and the indehiscent perithecia, or cleistocarps (mostly provided with appendages of a very definite form), containing non-septate ascospores. The family thus limited contains the genera *Podosphaera*, *Sphaerotheca*, *Uncinula*, *Microsphaera*, *Erysiphe*, and *Phyllactinia*.

The limitation of the Family *Erysiphaceae* to these six genera is not in universal use. Saccardo in the "Sylloge" (307)* divides the family into two sections: *Amerosporae*, with the characters "sporidiis ovoideis continuis hyalinis" contains the above six genera; the other, *Dictyosporae*, "sporidiis clathrato-septatis" includes the single genus *Saccardia*. Saccardo has, however, in a later work (313) excluded *Saccardia* from the family. Karsten (196) creates the sub-family "*Erysipheae* Karst." to include as well the genera *Capnodium*, *Perisporium*, *Anixia*, and *Eurotium*. Schroeter (319) includes in the family *Apiosporium* and *Lasiobotrys*, and Jaczewski (176) *Eurotium*, *Apiosporium*, *Dimerosporium*, and *Microthyrium*.

The muriform spores of *Saccardia* seem sufficient to place this genus outside the *Erysiphaceae*; *Apiosporium*, *Dimerosporium*, *Lasiobotrys*, and *Capnodium* differ in the black mycelium, etc.; *Eurotium* and *Anixia* are saprophytic; *Perisporium* has septate spores, and *Microthyrium* is far removed in the scutiform, not cleistocarpous perithecia. All these genera, also differ in not possessing the "*Oidium*" form of conidia.

The *Erysiphaceae* belong to the Order *Perisporiales* of the Class *Ascomycetes*. In the same order is the Family *Perisporiaceae*, to which the *Erysiphaceae* show nearest relationship. The closed perithecium, or cleistothecium, as it is sometimes termed, of the present family, must be considered as showing a low degree of development, and places the *Erysiphaceae* (together with the *Perisporiaceae*) among the simplest forms of the *Ascomycetes*. The characteristic feature of the *Erysiphaceae* is their true parasitism: the small size of the perithecia, and the abundant formation of conidia, capable of quickly infecting new hosts, must perhaps be considered rather as being adaptations to this mode of life than as primitive characters. Too much significance must not be attached to the presence of appendages to the perithecia. These appendages are strictly homologous to the mycelial outgrowths from the external cells at the base of the perithecium which occur in many genera of the *Ascomycetes*. In the Family *Ascobolaceae* of the Order *Pezizales* these outgrowths (called collectively the "secondary mycelium" by Woronin) re-

* The numbers refer to the Bibliography given at the end of the volume.—ED.

call at once the appendages of some species of *Erysiphe* (see Woronin, Beitr. Morph. Phys. Pilz. **2**: 3, *pl. 2. f. 7, 8*). We must remember, too, that in *Erysiphe* and *Sphaerotheca* the appendages are often obsolete. The function of this "secondary mycelium" is, generally, to secure the attachment of the perithecium to the substratum; in the *Erysiphaceae* the outgrowths have apparently been specially modified for purposes of distribution.

Harper (161) has some interesting remarks on the subject of the relationship of the *Erysiphaceae.*

MORPHOLOGY AND LIFE-HISTORY.

The ordinary vegetative mycelium consists of very numerous, delicate, white or colorless septate hyphae, frequently branched and more or less densely interwoven. The septa divide the hyphae into rather long cells, which according to Harper (161) contain, as a rule, only one nucleus, although cases where two to four nuclei occur are not uncommon. In all the genera except *Phyllactinia*, the hyphae of the vegetative mycelium produce haustoria at intervals which pierce the cuticle and swell out into a bladder-like form in the epidermal cells. These haustoria serve both to attach the fungus to its host and to draw nourishment from it. The haustorium is very narrow at the point where it pierces the cell-wall, and is frequently, at its entrance into the interior of the epidermal cell, surrounded by a sheath-like process proceeding from the cell-wall (see Fig. 155). According to Harper (161) each haustorium contains a single nucleus, situated towards the end, or in the middle of the bladder-like swelling or sac. This sac applies itself closely to the nucleus of the epidermal cell, and at length is completely surrounded by this nucleus, which gradually becomes disorganized, forming a thick granular coat round the haustorium. Finally, the whole of the protoplasmic content of the host cell becomes disorganized. The haustoria originate from the mycelium in three different ways; they may spring direct from the under surface of a hypha at a point where it is closely applied to the surface of the host plant, and at once pierce the cuticle. These are termed *haustoria exappendiculata;* or at certain places, at the side of the hypha, flattened semicircular processes appear, usually small, not exceeding in width the diameter of the hypha, and from the under sur-

face of these (which are closely appressed to the cuticle), or from the hypha itself at the point where the swelling originates, the haustoria are produced in the usual manner—these are termed *haustoria appendiculata;* or, finally, the hyphae are sometimes provided with processes, often on both sides at the same point, which are more or less deeply lobed or crenulate at the margin, or reniform in shape, and from these swellings, or from the hypha itself adjacent to them, the haustorium proceeds—these are *haustoria lobulata* (Fig. 128).

The genus *Phyllactinia* shows some important differences in the manner of producing haustoria. As pointed out by Palla (264), in his valuable paper, the vegetative mycelium on the under surface of the host-leaf does not send haustoria into the epidermal cells, but forms special hyphal branches, of limited growth, which enter the stomata, penetrate into the intercellular spaces, and finally send haustoria into the surrounding cells of the spongy-parenchyma (Fig. 163). Each of these special branches, or "Ernährungshyphe," consists of two, three, or rarely more cells, and is sometimes sufficiently long to extend through the spongy-parenchyma to the palisade-cells, but no haustorium has been observed to be formed in the cells of this layer. Each "Ernährungshyphe," of which sometimes two pass through the same stoma, produces a single haustorium, in all cases, from its last cell. Sometimes two haustoria (produced by different hyphae) are found in one cell. The haustorium itself does not differ from that found in the other genera of the *Erysiphaceae*.

With the exception of the haustoria, and the special branches of *Phyllactinia*, the mycelium of the *Erysiphaceae* is entirely superficial, *i. e.*, external to the tissues of the host-plant. In the rose mildew, *Sphaerotheca pannosa*, it has been frequently stated that the mycelium hibernates during the winter months within the tissues of the host-plant, but this statement appears to rest merely on supposition.

The first kind of reproductive bodies borne by the mycelium are the asexually-produced conidia, which are formed under favorable circumstances, throughout the summer and during the early part of autumn. The mycelium produces special hyphal branches, the conidiophores, which are erect, simple, colorless or white, thin-

walled, one-to-many septate, about 10 μ thick, and from 110 to 380 μ high. From these the conidia are formed by abstriction, either singly at the apex or in long chains in basipetal succession. The conidia are continuous, *i. e.*, non-septate, colorless or white, oblong, cylindrical, or barrel-shaped, smooth, thin-walled, and from 20–50 × 10–24 μ in size. Harper (161, p. 664) states that a single nucleus passes from the parent-hypha into the young conidiophore, and that from it arise the nuclei of all the conidia subsequently formed.

Conidial forms of the *Erysiphaceae* were formerly classified as an autonomous genus of the *Hyphomycetes* under the name of *Oidium*. It soon became observed, however, that the *Oidium* was frequently succeeded by species of the *Erysiphaceae*, or that the *Oidium* even occurred among the perithecia of the latter. Berkeley in 1841 (26, see also 29) was among the first to give conclusive evidence of the organic connection of the *Oidium* with the *Erysiphaceae*. It is now well known that during the stage in which the conidial form is just passing over into the perithecial, conidiophores and perithecia may frequently be observed in organic connection.

The conidia are usually formed in immense numbers throughout the summer, and being easily carried by the wind, are the means of rapidly spreading the fungus during the growing season. It may be noted that Wagner (380) observed in several instances the distribution of conidia effected by snails, and mentions that the conidia of *Erysiphe polygoni* on plants of *Hypericum* by this means were carried to plants of *Aquilegia*, and those of *Sphaerotheca Castagnei* on *Impatiens* to other plants (see also Stevens (340*)).

The conidia are capable of immediate germination on reaching the epidermis of a suitable host-plant. Even in a dry atmosphere, but more readily in a damp one, or in water, one or more delicate germinal tubes are produced near one end of the conidium. Soon the first haustorium is formed (sometimes immediately on germination), and from this center hyphae grow out, branching, crossing, and developing haustoria. The vegetative mycelium thus formed continues to develop, and under favorable conditions begins to produce conidia in a few days.*

* Dangeard (96) has observed cases of conidiophores being produced direct from the germinating conidium.

The second phase in the life-history of the *Erysiphaceae* occurs later in the summer, or in autumn, usually when the vitality of the host-plant begins to diminish. The formation of conidia is then gradually superseded by that of perithecia, containing ascospores, or resting-spores, whose function is to carry the fungus in a dormant condition through the winter, when host-plants are not available.

The history of the development of the perithecium was first investigated by de Bary (98 and 99). At the crossing point of two hyphae, or at the place where two neighboring hyphae touch, each develops a small upright branch, which is soon cut off by a septum from the parent hypha. One of these branches swells to an oval-oblong shape, and becomes the oögonium. The other lengthens slightly, and applies itself closely to the side of the oögonium, curving above so that its end lies on the apex. The uppermost part is then cut off by a septum, and forms the antheridium.

De Bary observed no breaking down of the wall between the antheridium and the oögonium, and so supposed that no conjugation took place, but nevertheless considered that these organs represented a true sexual apparatus, and that the perithecium subsequently formed was to be regarded as the result of a sexual act. This last conclusion has lately been strikingly verified by the work of Harper. The following details are taken from the two important papers of this author (160 and 161).

The oögonium and antheridium each contain a single nucleus. At the time of fertilization the cell-wall between the two organs is dissolved, and the nucleus of the antheridium enters the oögonium, and unites with its nucleus. At this point the protoplasm of the antheridium is in direct contact with that of the oögonium; soon, however, after the passing over of the nucleus of the antheridium into the oögonium, a fresh wall is formed between the two organs, and then only a small quantity of protoplasm is found in the antheridium. At the time when the union of the two nuclei takes place, the development of the walls of the future perithecium begins. From the stalk cell of the oögonium a number of hyphal branches spring, closely pressed side by side, and grow upwards, forming a single layer round the oögonium. The stalk cell of the

oögonium then swells to a circular shape, and a second series of hyphae, internal to the first, grow up in a similar manner. The hyphae of both series branch and intertwine, completely growing together, and forming finally a pseudo-parenchymatous tissue. A number of branches grow from the internal layers of this primary coat towards the interior of the developing perithecium and, repeatedly branching, fill up all interstices. The cells of these branches, which are very rich in protoplasm and contain several nuclei, disappear in the course of the growth of the perithecium, becoming absorbed by the developing ascus or asci. The cells of the outer layers become greatly flattened, and lose their protoplasmic contents, the external ones becoming dark brown and forming the outermost wall of the perithecium.

The oögonium after fertilization is known as the carpogonium, and undergoes certain changes, which vary slightly according as one or several asci are formed.

In *Sphaerotheca*, where a single ascus is found, the following growth takes place. At about the time when the two primary layers of hyphae have grown up from the stalk-cell, the carpogonium begins to elongate, and nuclear division takes place, resulting in the formation of a single, more or less curved row of five or six cells. In the penultimate cell of this row two large nuclei are always present, while the other cells contain only one each. This penultimate cell is the young ascus. It swells strongly, so that the apical cell of the series is pushed aside and downwards, and finally absorbed. The two nuclei now fuse, and the ascus rapidly increases in size, pressing together and flattening the cells of the inner layers of the young perithecium. The nucleus increases in size, and finally divides three times, providing the nuclei for the eight ascospores which are subsequently produced by free-cell formation. In *Erysiphe*, where several asci are produced in the perithecium, the development is, with slight modifications, the same as that of *Sphaerotheca* (see Harper (161)).

The fusion of the nuclei in the young ascus is evidently to be regarded as a vegetative one, similar to that which occurs in basidia, cystidia, and the asci of the other fungi—even sometimes, according to Massee (240), in the hairs of some of the *Discomycetes*. Dangeard (96) however, regards the fusion of

nuclei in the young ascus as of sexual significance, and denies the primary sexual fusion of the nuclei of the oögonium and antheridium; but, as Wagner (379*) points out, the weight of evidence is against accepting Dangeard's theory.

When the perithecia are about half-grown, certain cells of the outer wall, situated either apically, equatorially, or basally begin to grow out into the appendages. These appendages, if basal, may be floccose and more or less similar to the hyphae of the mycelium, with which, as in the genus *Erysiphe*, they are frequently interwoven; usually, however, they are quite distinct from the myselium, erect or radiating, and sharply characterized in shape. In *Phyllactinia* they are acicular and bulbous at the base (figs. 170, 171); in *Uncinula* hooked at the apex (see Plates 4 and 5), and in *Podosphaera* and *Microsphaera* they are variously branched in a dichotomous manner (see Plates 1 and 2).

It is difficult to say definitely what part the appendages play in the life-history of the *Erysiphaceae*, although it is generally supposed that they are concerned with the distribution of the perithecia (see Gardner, 142).

The perithecium of *Phyllactinia*, besides the acicular appendages, possesses a basal mass of special branched hyphae, which certainly serve in the first place to attach the perithecium to the leaf, and in some cases, perhaps many, causes it subsequently to adhere to foreign substances.

The asci contained in the perithecia are colorless sacs, stalked or sessile, globose to cylindrical in shape, and from one to 66 (or more) in number. They contain from two (or abnormally only one) to eight spores. The wall of the ascus is from 1–5 μ thick, and usually becomes very thin at the apex of the ascus. No true paraphyses are present, although this name has been given by some authors to the isolated portions of the inner wall, often of a filiform shape which sometimes occurs in the perithecia (especially in *Phyllactinia*).

The ascopores are colorless, continuous (*i. e.*, non-septate), granular, oval, oblong, or occasionally roundish, with obtuse ends, rarely slightly curved, 15–34 (rarely reaching 50) × 8–25 μ in size.

The perithecia are truly cleistocarpous, the asci being liberated by the irregular rupture of the wall. This takes place in the

spring following the season in which the perithecia were produced. In some cases, as in *Erysiphe galeopsidis*, and, as a rule, in *E. graminis*, the ascospores are not formed until the following spring, the protoplasm of the asci remaining throughout the winter in a granular condition. It appears that the ascospores are incapable of immediate germination, and require to pass through a resting stage, lasting the winter months. Galloway (139) and also Worthington G. Smith (329) state that in the spring the perithecia, under favorable conditions, suddenly burst and forcibly eject the asci. Harper (161, p. 663) mentions that the cells of the inner wall of the perithecium permanently retain their nuclei and protoplasmic contents, and suggests that they may produce a substance capable of swelling in water, and so causing the rupture of the perithecium.

The ascospores in a damp atmosphere or in water send out in a few hours germ tubes, which (according to Wolff) on reaching the epidermis of a suitable host-plant penetrate and form a haustorium, from which center the ordinary vegetative mycelium is produced. Very little, however, is known on the subject, and no records exist, apparently, of any artificial infection of host-plants by means of ascospores. Galloway (139) has made some valuable observations on the ripening and germination of the ascospores in *Uncinula necator* and Wolff (398, 399) in the case of *Erysiphe graminis*, and Tulasne has recorded cases of the commencement of germination of the ascospores of *Phyllactinia corylea*, *Sphaerotheca pannosa* and *Erysiphe tortilis*.

With the formation of perithecia the mycelium frequently entirely disappears. Sometimes, however, as in *Sphaerotheca pannosa* and *Erysiphe graminis*, it is persistent, and produces special branches in the form of long, branched, interlaced, shining, thick-walled hyphae, in which the perithecia are more or less immersed. It has been stated that in certain species, viz, *Sphaerotheca pannosa*, *Podosphaera oxyacanthae*, *P. leucotricha* and *Uncinula necator*, the mycelium is perennial, passing the winter months in a state of hibernation; definite proof of this, however, has not been given in any case.

It is sometimes found that perithecia, which externally present the normal appearance, instead of containing asci, emit when opened

a stream of very small, biguttulate spores, 6.5–10.5 × 3.5–6μ in size, immersed in a colorless mucilaginous substance. In such cases there may usually be found on the same mycelium paler and smaller bodies, globular, oval, or pyriform in shape, without appendages, and containing the same kind of spores. Similar bodies are frequently formed in the joints of the conidiophores when they usually bear at their apex the shrivelled remains of the chain of conidia.

Prior to De Bary's searching investigations into this subject in 1870 (99), these bodies were known as pycnidia, and the contained spores as stylospores, and by the older botanists were thought to be another form of reproduction of the *Erysiphaceae*. De Bary, however, showed that the pycnidia and spores belonged to a minute fungus living parasitically within the hyphae of species of the *Erysiphaceae*. The vegetative mycelium of this parasitic fungus (*Ampelomyces quisqualis*) is composed of a great number of closely septate hyphae, which run singly inside the hyphae of the host. The fruit of the *Ampelomyces* is produced either in the perithecia, conidiophores, or cells of the host mycelium. If the species attacked is in the perithecial stage, the parasite forms its fruit in the interior of the perithecium, absorbing the asci and sometimes sending its hyphae into the appendages. The variation in shape of the pycnidia is due to the difference in the maturity of the perithecia attacked. If the host is in the conidial condition, the fruit of the *Ampelomyces* is produced in the transformed cells of the conidiophores, and in this case the presence of the parasite seems to prevent any subsequent formation of perithecia.

De Bary succeeded in infecting germinating conidia of species of the *Erysiphaceae* with the spores of *Ampelomyces*, and found that the latter on germination at once penetrated the germinal hyphae of the conidia. In some cases, the spores of the *Ampelomyces* germinated after they had been kept for three months in a dried condition. They are, therefore, probably capable of infecting fresh hosts after passing through the winter in a resting state. *Ampelomyces* has been observed on most of the species of the *Erysiphaceae*, and no doubt plays an important part in checking their spread, by lessening their vitality, and often preventing the formation of perithecia (see Griffiths, 153, pp. 184, 185).

In the *Erysiphaceae*, as in other groups of parasitic fungi, we find that in some years, from unknown causes, the species attack certain host plants in a marked manner. This is well illustrated by the wave of disease, caused by *Sphaerotheca humuli*, which periodically sweeps over the cultivated hop, and in the attacks, by the same fungus, in certain years on cultivated strawberries; and it is not the less noticeable with regard to wild host-plants. Some interesting biological notes, on this and other points, are given by Griffiths, in his paper on "Some Northwestern *Erysiphaceae*" (152).

The frequency with which great devastation is caused by members of the present family to cultivated plants of high economic value makes the study of their life history a matter of importance. The two worst diseases are those caused by the vine and hop mildews (*Uncinula necator* and *Sphaerotheca humuli*), which at certain periods have caused wholesale destruction to the cultivated vines and hops of the world. Other well-known diseases are caused by the rose mildew (*Sphaerotheca pannosa*), the apple mildew (*Podosphaera leucotricha*) and the pear and cherry mildew (*P. oxyacanthae*), the gooseberry mildew of America (*Sphaerotheca mors-uvae*) and the gooseberry mildew of Europe (*Microsphaera grossulariae*), the pea, bean and turnip mildew (*Erysiphe polygoni*), and the corn mildew (*E. graminis*).

All these diseases, it is now proved, are able to be held in check by the prompt use of certain fungicides. I have endeavored to give full instructions for the preparation and use of the best remedies under each species of mildew causing a disease.

HISTORICAL

Linnaeus in the *Species Plantarum* (1753) mentioned a fungus under the name of *Mucor Erysiphe*—"Mucor albus, capitulis fuscis sessilibus. Habitat in foliis *Humuli, Aceris, Lamii, Galeopsidis, Lithospermi.*" By this name the four species of the *Erysiphaceae* now known as *Sphaerotheca humuli, Uncinula aceris, Erysiphe galeopsidis* (on *Lamium* and *Galeopsis*) and *E. cichoracearum* were in all probability intended. In 1767, in the "Mundus Invisibilis" (222) Linnaeus spoke of *Erysiphe* as a genus (giving, however, no strict definition). Persoon, in 1796 (Obs. Myc. 1: 13), gave the

name *Sclerotium Erysiphe* to Linnaeus' species, and in 1801 (Syn. Meth. Fung. 1: 124) separated the plant on *Corylus* as var. *β corylea* (= *Phyllactinia corylea*).

In 1804, in a work by Rebentisch (295) we meet with the first illustration. The fungus was called *Sclerotium suffultum*, and represents the species now known as *Phyllactinia corylea.*

In 1805 De Candolle (62) published the mss. genus "*Erysiphe* Hedw. f.," and very briefly described, often under several different names depending on the host-plant, the species now known as *Phyllactinia corylea*, *Uncinula salicis*, *Erysiphe polygoni*, *E. cichoracearum*, and *Microsphaera berberidis.* De Candolle in 1806, in the Syn. Pl. Gall. added *Erysiphe aceris* (= *Uncinula aceris*); in 1807 (64) *E. oxyacanthae* (= *Podosphaera oxyacanthae*), and in 1815, in vol. 6 of the Flore Française the species now called *Microsphaera euonymi*, *M. astragali*, *M. alni* var. *lonicerae*, *Sphaerotheca humuli*, *Uncinula prunastri*, *Erysiphe graminis* and *E. galeopsidis.*

In 1815, also, Bivoni Bernardi (41) described and figured *Erysiphe vagans* (= *Phyllactinia corylea*) and *E. clandestina* (= *Uncinula clandestina*). The figures of both are good, and in that of the latter species the uncinate apex of the appendages is carefully shown.

In the same year Fries in Obs. Myc. p. 206, united all the hitherto described species under the name of *Erysiphe varium.*

The alteration of the spelling of the genus to "*Erysibe*" originated with Nees von Esenbeck, in 1817 (257), who used the name "*Erysibe suffultum* Rebent." for the *Erysiphe suffultum* of that author, and subsequent authors followed in attributing the word "*Erysibe*" to Rebentisch.

In 1819 the most important of the early works on the *Erysiphaceae* appeared. These were Wallroth's two papers, one entitled "Naturgeschichte des *Mucor Erysiphe*," in the Berlin Gesell. Nat. Freunde Verhandl. 1: 6–45; the other, called "De *Mucore Erysiphe* Linnaei observationes," in the Annal. Wett. Gesell. 4: 226–247.

Through Wallroth's work an important addition was made to the existing knowledge of the family. It may be said that in all works prior to this date the host-plant on which the *Erysiphe* grew afforded the chief specific character. Wallroth pointed out that the same species often grew on a great number of different host-

plants and insisted on the need of each species being defined by morphological characters. Attention was also directed to the value of the appendages as affording diagnostic characters, and the various shapes and mode of branching shown by these organs were carefully noted.

With respect to nomenclature, Wallroth made some unfortunate changes. Regarding the name *Erysiphe* as unsuitable (on account of its derivation from the Greek word 'ερυσίβη, which is stated to have meant *robigo*, or rust), Wallroth proposed *Alphitomorpha* in its place, and used the name *Erysibe* to supersede the genera *Uredo*, *Ustilago*, etc. These changes, however, were not adopted by subsequent authors, and it need only be mentioned that in accordance with the laws of botanical nomenclature, Wallroth's reasons for overthrowing the name *Erysiphe* for the present group are insufficient.

An appendix by Schlechtendal immediately followed Wallroth's paper in the Berlin Verhandl. This work is especially interesting from the fact that it is here for the first time clearly recognized that the *Erysiphaceae* may be divided into two groups, one in which the perithecia contain a single ascus with eight spores, the other in which these contain several asci. This important fundamental difference is well shown in a figure.

From 1819 until 1851 little advance was made.

In 1823 Kunze (208) founded the genus *Podosphaera* for the "*Sphaeria myrtillina*" of Schubert, and gave good figures illustrating the characters of the genus.

Link, in 1824, in Willdenow's "Species Plantarum," arranged the species described up to that time in two sections, "sporangiolo unico," and "sporangiolis pluribus."

In 1825–27 Greville, in the Scottish Cryptogamic Flora, described and figured *Erysiphe pisi* (= *E. polygoni*), *E. adunca* (= *Uncinula salicis*), and *Eurotium rosarum* (= *Sphaerotheca pannosa*).

Perhaps the most important works about this time were Fries' Syst. Myc. (1829), Duby's Botanicon Gallicum (1830), and Wallroth's Fl. Crypt. Germ. (1833), although they added but little to the existing knowledge of the *Erysiphaceae*.

In 1834 Schweinitz (322) published an account of the North American forms, in which sixteen new species were described;

many of these, however, were the same species on different host plants.

In 1838 Corda (92) figured *Erysiphe Perisporium* (= *E. polygoni*) and *E. bicornis* (= *Uncinula aceris*).

During 1846–9, Durieu and Montagne (109) described several species from Algeria.

In 1851 Léveillé published in the Ann. Sci. Nat., his classical monograph entitled "Organisation et Disposition méthodique des espèces qui composent le genre Érysiphé." In this work after dividing the *Erysiphaceae* into two sections, "Sporangium unicum" and "Sporangia plurima," Léveillé arranged the species in five genera, viz, *Podosphaera* Kze. and *Sphaerotheca* Lév. belonging to the first section, and *Phyllactinia* Lév., *Uncinula* Lév., *Calocladia* Lév. (afterwards changed to *Microsphaera* (see *l. c.*, 381) and *Erysiphe* Hedw. f. DC. (emend.) belonging to the second.

These genera, based on characters shown by the appendages, are still found to embrace all the known species of the *Erysiphaceae*. For establishing these extremely natural genera, and for the broad view shown in the treatment of species, Léveillé's work has long been recognized as of the highest value.

In 1861 the brothers Tulasne described fully and illustrated sixteen species of the *Erysiphaceae* in the first volume of the Selecta Fungorum Carpologia. The five plates, engraved on copper, contain the most beautiful illustrations of the family existing, and show well the stages in the life-history of both the conidial and perithecial form. The genera established by Léveillé are not kept up, the species all being referred back to the old genus *Erysiphe*.

In 1870 De Bary's great work on *Erysiphe* in the "Beiträge zur Morphologie und Physiologie der Pilze" appeared. Here the general life history of the *Erysiphaceae*, and especially the history of the development of the perithecia, were minutely investigated. In a systematic appendix De Bary divided the family into two genera—*Podosphaera*, with the characters "carpogonia orthotropa. Ascus in quoque perithecio unicus (rarissime, lusu, 2), octosporus; and *Erysiphe*, "carpogonium campylotropum. Asci in quoque perithecio 4 aut plures."

In 1872 Cooke and Peck published their papers (90 and 91) on

the *Erysiphaceae* of the United States, describing a number of new species.

Karsten (1873) in Myc. Fenn. (192) and, later (1885) in the Act. Soc. Faun. Fl. Fenn. (196) described the *Erysiphaceae* of Finland, and in 1884 Winter monographed those of Germany in Rabenhorst's Krypt. Fl. Deutschl. (394).

In 1887 the important work entitled the "Parasitic Fungi of Illinois, Part 2, *Erysipheae*" by Burrill and Earle appeared. It would be difficult to praise this work too highly for the clear descriptions of the species (28 in number), the careful enumeration of the host-plants, and especially for the broad view shown in the conception of what constitutes a natural species. Burrill's excellent account of the North American species in Ellis and Everhart's N. Amer. Pyrenomycetes (1892) is based on the above work, and contains some important additions.

In 1893 Schroeter enumerated the *Erysiphaceae* in Cohn's Krypt. Fl. von Schlesien, in 1896, Jaczewski published his "Monographie des Erysiphées de la Suisse" (176), and in 1897 Oudemans described the species found in the Netherlands (263).

In 1895 Harper's valuable work (160) on the history of the development of the perithecium appeared.

At the beginning of 1899 Palla published his important paper "Ueber die Gattung *Phyllactinia*." It is here pointed out that *Phyllactinia* differs from the other genera in producing its haustoria from hyphae sent through the stomata of the host-leaf. As a result of this interesting discovery, the *Erysiphaceae* are now divided into two sub-families, the *Erysipheae* and the *Phyllactineae*.

In Saccardo's "Sylloge Fungorum" (1882–1899) an enumeration of all the published species of the *Erysiphaceae* is given. Meschinelli (248), in his work on fossil Fungi, describes and figures a genus *Erysiphites*, with one species (= *Erysiphe protogaea* Schmalh.) found on *Ficus kiewiensis* in one of the Tertiary formations in Russia.

GENERAL REMARKS ON THE CONNECTION BETWEEN HOST AND PARASITE

In the *Erysiphaceae*, perhaps as much as in any group of fungi there has been, especially in the past, an undue multi-

plication of species. For example, more than twenty forms of *Phyllactinia corylea* (notwithstanding that this is the most sharply characterized species in the family) have been published as new species. For the most part, these "species" were supposed to be confined to the host-plant on which they were discovered, and after which they were named; this was the case with *Erysiphe fraxini*, *E. betulae*, *E. alni*, *E. mali*, *E. fagi*, *E. quercus*, *E. pyri*, *E. ilicis*, *E. cerasi*, etc.

It is interesting to note that even among the earlier authors this unscientific practice of making a new species of a form because it occurred on a new host-plant did not pass unreproved. As early as 1819 Wallroth (383, p. 18) says: "Es ist ein ganz irriger Glaube und ein unverzeihlicher Fehler der Flüchtigkeit, wenn wir * * * so viel Arten der Epiphyten aufgestellt und nach den Pflanzen selbst, auf denen sie hervorbrechen, benennt finden als deren selbst sind." Again, in 1851, when Léveillé arranged in clearly defined species the great mass of named forms (often distinguished merely by the host on which they grew) which had accumulated since Wallroth's time, the same warning is repeated; "Pour les reconnaître on devra les étudier seulement quand ils auront atteint leur plus haut degré d'organisation et ne plus faire attention aux végetaux sur lesquels on les rencontre. Cette manière de les dénommer est essentiellement vicieuse, elle conduit à la confusion et à l'erreur."

In Saccardo's "Sylloge" 111 species, and 1 variety, and 20 species "dubiae vel inquirendae," are enumerated. To this number must be added 8 species and 6 varieties, either accidentally omitted from the Sylloge, or published subsequently.

In the treatment of the family in the present paper 49 species and 11 varieties are recognized. Of these three species and two varieties are new to science.

This great reduction of species will not be wholly unexpected, as a similar process has been found necessary in the treatment of the family by several authors, in works published subsequently to the "Sylloge." Winter, for instance, in his work on the *Erysiphaceae* of Germany, reduced several of the European species enumerated in the "Sylloge," and in 1887 Burrill and Earle (61) similarly accounted for many of the American species of Schweinitz,

as well as for several of those described by later American authors.

The further reduction of species that has been made in the present work may be ascribed mainly to two causes: (1) The necessity of adopting a wide view of a species when dealing with material from all parts of the world; and (2) The adoption of the principle that classification must be based primarily on morphological characters.

As a necessary consequence of adherence to the latter view, the connection of a parasitic fungus with a certain host-plant cannot be considered as affording a character of specific importance. If it were to be proved that two forms of a fungus, morphologically indistinguishable from one another, occurring on different species of host plants, were incapable of infecting any but their respective hosts, then these two forms might be classified as "biological" varieties or species, and in such a case the connection between the parasite and its host would become a character of systematic importance. No such evidence, however, is at present adduced in connection with the members of the *Erysiphaceae*. For the present, therefore, to mention one example, such a species as *Sphaerotheca epilobii*, supposed to be confined to species of *Epilobium*, but morphologically indistinguishable from certain forms of the polymorphic *S. humuli*, cannot be maintained.

The question of the systematic value of the connection between host and parasite is one of great importance. The connection is frequently treated as affording a character of primary specific importance, and it will, perhaps, not be out of place here to utter a protest against this practice. The method of classification commonly followed in dealing with parasitic fungi is well illustrated in the treatment the genus *Phoma* has received. Over 1,000 species are enumerated in Saccardo's "Sylloge," and the majority of these are named after the host-plant on which they occur. That the connection of parasite and host is here made the character of primary importance can be seen from the treatment of the genus given in local floras. Allescher in enumerating 570 species of *Phoma*, in Rabenhorst's Kryptogamen Flora Deutschlands, has adopted an arrangement thus described: "Die Arten der

Gattung *Phoma*, sind im Folgenden je nachdem sie auf Holzgewächsen, krautartigen Dicotyledonen, Monocotyledonen, oder Kryptogamen wachsen, und in jeder Abtheilung nach den alphabetisch geordneten Nährpflanzen angeordnet." When in place of such an arrangement as this, where the connection between host and parasite is considered of primary specific importance, and where a mere alphabetical list is substituted for a natural classification, a monograph of the genus *Phoma* appears in which the species are defined by morphological characters, a more scientific method in the classification of fungi will have commenced.

After the forms of the *Erysiphaceae* have been grouped around what may be termed "morphological centers," the next most important work is to experiment biologically with them. Such experimental work remains, unfortunately, almost entirely to be done. A few instances are on record of attempts to sow the spores of one species on the host-plants peculiar to another species, *e. g.*, the spores of *E. graminis* on the host-plants of *E. polygoni*, and those of *E. polygoni* on the vine, the host-plant of *Uncinula necator;* in all cases without success.

An experiment performed by Magnus (mentioned in detail under *Sphaerotheca*), although unfortunately incomplete, is of great interest. Conidia of *Sphaerotheca humuli* growing on the hop, were taken and sown on *Taraxacum officinale*, a common host-plant of *S. humuli* var. *fuliginea*. This variety (considered a distinct species by Burrill and most American authors) is distinguished by the much larger cells of the perithecium, usually different character of the appendages, etc. The conidia of *S. humuli* germinated on the *Taraxacum*, and produced a mycelium bearing conidia. Observations were not continued to see if perithecia would be produced. From this experiment we are led to one of three conclusions. We must suppose either: (1) That the conidia of *S. humuli* on this host would have produced ultimately the perithecia at present considered characteristic of the var. *fuliginea*, in which case we should have to consider the latter as merely a form of *S. humuli* induced by growing on certain host-plants. This view is rather favored by the fact that in some species we have certain forms associated with certain hosts which present slight morphological differences, although these are not

sufficiently marked to prevent the forms from being considered as belonging to the species. Or (2) We must suppose that the conidia of *S. humuli* on a strange host-plant, although producing a mycelium capable of giving rise to conidia, might be unable to continue its development and produce perithecia, in which case the form would quickly die out. Certain *Oidium*-forms, *e. g.*, that on species of *Myosotis*, appear seldom, if ever, to produce perithecial fruit. Finally, (3) That the conidia might have ultimately produced perithecia similar to those of ordinary *S. humuli*. This seems perhaps unlikely, when we remember that *S. humuli* has never been recorded on *Taraxacum*, notwithstanding that this plant is a common weed in many places (*e. g.*, hop-gardens) where *S. humuli* grows.

The compilation of a list of the host-plants of the *Erysiphaceae* is attended with many difficulties.

1. In the first place the fungus has frequently been wrongly determined in Exsiccati. An instance will make this clear, and illustrate how wrong plants may become recorded as hosts for certain species. In eleven examples from certain Exsiccati "*Sphaerotheca Castagnei*" is given as the species occurring on these hosts:—*Inula hirta* (Sacc. Myc. Ven. 630), *Plantago maritima* (Rab. Fung. Eur. 1916), *P. major* (Rab. Fung. Eur. 1048), *Achillea Ptarmica* (Rab. Fung. Eur. 1051), *Senecio sylvaticus* (de Thüm. Fung. Austr. 441), *Eupatorium cannabinum* (Cooke, Fung. Brit. Exsicc. ed. 2, 591, 592), *Trifolium medium* (Syd. Myc. March. 3052), *Calystegia sepium* (Syd. Myc. March. 432), *Catalpa syringaefolia* (Syd. Myc. March. 1640), *Falcaria vulgaris* (Syd. Myc. March. 1541) and *Stachys alpina* (Sacc. Myc. Ven. 1491). In the first six specimens the fungus is *Erysiphe cichoracearum*, in the next four *E. Polygoni* and in the last *E. galeopsidis*. Here we have eleven species of host-plants wrongly given for one species in specimens sent out in exsiccati. It is, moreover, probable that the error does not stop here, but that it is perpetuated by the fungus on these hosts being named and recorded as "*S. Castagnei*" without examination by subsequent collectors; it is significant that four of the plants given above are stated to be hosts of *S. Castagnei* by several authors.

2. The list of host-plants has been further complicated by the

practice followed by many authors of determining a plant specifically in its conidial (*Oidium*) stage. As yet, we do not know enough about the conidial form (which is possibly as variable in some species as the perithecial is known to be) to be able to determine it specifically with safety, and it is certain that the practice of doing so had led to many errors. I have, therefore, as far as it has been possible, omitted in my host-index those records in which the fungus has been observed only in the conidial condition. The treatment which the fungus on *Cucurbitaceae* (*Cucumis*, *Cucurbita*) has received, affords evidence of the danger of naming the conidial forms. In herbaria and published records the fungus is stated almost without exception, to be *Sphaerotheca Castagnei*. Schroeter, however, having observed the perithecial stage on *Cucurbita Pepo*, has named it *Erysiphe polygoni*. In collections and exsiccati this fungus on *Cucurbitaceae* exists apparently only in the conidial stage, and the only specimen that I have seen with perithecia occurred on *Cucurbita Pepo*, in late autumn, at Reigate, Surrey, England. On this specimen the fungus is undoubtedly *Erysiphe cichoracearum*, the species recorded on *Cucurbitaceae* by American mycologists.

3. Certain common species of *Erysiphe* are, in my experience, always wrongly determined. In Europe there is a species, not uncommon on *Valeriana officinalis* which, without exception, has been referred to *E. communis* (*E. polygoni*) by authors; it is, however, undoubtedly *E. cichoracearum*. The fungus not uncommon on *Anchusa officinalis* and *Echium vulgare* has been named *E. cichoracearum*, and no records exist of *E. polygoni* occurring on these hosts, yet all the specimens I have seen in herbaria are really to be referred to the latter species. The only fungus on *Galium* that I have seen is *E. cichoracearum*, yet it is always named in European herbaria and exsiccati *E. communis* (*E. polygoni*), and is so recorded in all works.

I have thought it advisable, therefore, on account of the confusion that exists in many cases, to compile a host-index from personal observations, chiefly with the view of seeing if any facts of interest could be gained on the subject of the general relation between parasite and host. By means of the abundant material received from many parts of the world, and through the examina-

tion of the chief herbaria, I have been enabled to observe the occurrence of species of the *Erysiphaceae* on 1002 different species of host-plants.* To make the list, as far as possible, complete, I have incorporated 367 additional host-plants recorded in the literature of the subject, and have also noted all those cases in which a different species of mildew to that personally observed on any host-species has been recorded by authors. In both the latter cases the plants are distinguished in the host-index by an asterisk, and the authority for each record is indicated in the list of host-plants given under the respective species of fungus. The names of the host-plants have been, so far as possible, brought into accordance with those of the Index Kewensis.

The restriction of the parasite in its choice of host-plants varies greatly in the species of the *Erysiphaceae*. Many species, *e. g.*, *Erysiphe tortilis* on *Cornus sanguinea*, *Uncinula geniculata* on *Morus rubra*, and *Podosphaera biuncinata* on *Hamamelis Virginiana* have a more or less wide geographic distribution, and yet, so far as at present known, are absolutely confined to their respective host-plant. About as many instances occur in which the hosts of the fungus are limited to one genus; *e. g.*, *Uncinula aceris*, its var. *Tulasnei*, and *U. circinata* are confined to species of *Acer*; *U. flexuosa* to species of *Æsculus*, and *Sphaerotheca lanestris* to species of *Quercus*. A few species are limited in their choice of host-plants to certain families, *e. g.*, *Uncinula salicis* on *Salicaceae*, *Sphaerotheca pannosa* on *Rosaceae*, *Erysiphe graminis* on the *Gramineae*. Finally, many species occur on a great number of

* A word may be given here on the right manner of using the host-index. Rightly used, it affords, when the name of the host-plant is known, a useful clue toward identifying an unknown species, and in a certain sense serves as a key to all the species of the *Erysiphaceae*, wrongly used, it may easily be the means of perpetuating errors. To illustrate, if there be but one species of fungus recorded on the host-plant in hand, it is then necessary merely to turn to the description of the fungus and see if the specimens to be named agree in the characters given. The practice of naming a fungus from a host-index, without examination, cannot be too strongly condemned. If several species have been recorded on the host, the description of each must be consulted until the fungus is identified. It is, perhaps, not unnecessary to add that if the name of the host-plant in hand is not to be found among those of the host-index, it is not to be assumed that this gives any reason for supposing that the fungus is a new species, as the host list is necessarily very incomplete; in such cases the keys to the genera and species must be consulted.

host-plants of very different affinities. I have observed *Phyllactinia corylea* on hosts belonging to 48 genera, in 27 different families, and *Erysiphe polygoni* on 190 different species of host-plants, belonging to 89 genera. The latter species has been reported on 146 additional host-plants (some of which, however, must be considered doubtful).

The members of the *Erysiphaceae* fall into the following divisions; 15 species and 2 varieties are confined to a single species of host-plant; 15 species and 5 varieties to species belonging to one genus; 4 species and 1 variety to those belonging to one family, and 15 species and 3 varieties show little or no preference in selecting their hosts. In the species of the first division it seems reasonable to suppose that the connection between host and parasite must be a very intimate one. In those of the last division it seems probable that the connection is slight.

The number of cases in which more than one species or variety of mildew has been observed on one species of host-plant is rather large; on one host-species five different mildews have been recorded in one case, four in four cases, three in 24 cases, and two in 163 cases. These numbers have been obtained by taking into account all the published records, and are therefore (especially with regard to those cases in which two species of mildew have been recorded on the same host) probably far too high. In the present confusion that exists concerning the hosts of many species it is impossible to give exact numbers; probably, in the last case mentioned, 100 in the place of 163 would be nearer the mark. In many cases it is probable that an error in identification has led to different species of the *Erysiphaceae* being recorded for one host-plant. For instance, on *Verbascum phlomoides* I have seen *Erysiphe taurica*; *E. cichoracearum* is recorded by Magnus, and *E. polygoni* by Dom. Saccardo; *E. cichoracearum* grows commonly on *Achillea Ptarmica*, and it may perhaps be doubted if the two other species—*E. taurica* and *E. polygoni*, recorded on this host, really occur. It is needless to give further examples, as these can be found in the host-index. On the one hand it is quite certain that in a large number of cases more than one species of mildew grows on one host-species; on the other hand, it is equally certain that in many of the recorded cases of this kind wrong determinations have been made. It is hoped

that by means of the asterisk prefixed to the plants in the host-index attention will be directed to this point, and so lead mycologists to clear up these doubtful records. The work is difficult, as it consists in many cases in proving that a certain species does not grow on a certain host-plant; this can only be hoped to be accomplished by continued observations for many years, at the end of which time it might be safe to disregard many published records.

One curious source of error still remains to be noticed. It has, up to the present, been generally supposed that it is a safe practice to consider perithecia found on any host-plant as originating there. Many cases that have come under consideration prove that this is not so. In some instances stray perithecia of certain species occurring on strange hosts have been published as new species. This is the case with "*Erysiphella Carestiana*," which was founded on perithecia of *Phyllactinia corylea* accidentally adhering to the pileus of *Fomes fomentarius*. "*Uncinula Coumbiana*" is, I believe, merely *U. salicis* on the leaves of *Scutellaria*, and "*Erysiphe vitigera*" appears to have been established on stray perithecia of *E. cichoracearum*, occurring on the vine. Similiar cases, mentioned in detail under the respective species are the following: *Uncinula salicis* on *Artemisia vulgaris*, *U. prunastri* on *Lonicera Xylosteum*, *U. Delavayi* on *Celtis*, *Phyllactinia corylea* on probably many herbaceous hosts and *Microsphaera alni* on *Populus grandidentata*. *Uncinula geniculata* has occurred apparently accidentally on *Hydrophyllum appendiculatum*. I have seen, in herbarium specimens, *Podosphaera tridactyla* adhering in a tangled mass to a leaf of *Fagus sylvatica*, and perithecia of *Phyllactinia corylea* accidentally present on a rose leaf. A few perithecia of *Microsphaera alni* have been seen among those of *M. diffusa* on a leaf of *Desmodium paniculatum*, and, also, in a specimen named *M. grossulariae*, adhering to the margins of gooseberry leaves.

The accidental presence of perithecia on plants may perhaps be accounted for in some cases by the rubbing together of dried specimens in herbaria, or possibly by the repeated use of the same drying paper to which perithecia would adhere, in pressing the leaves.

DISTRIBUTION.

The *Erysiphaceae* have practically a world-wide distribution. It can, however, be said that their headquarters are in the North Temperate Zone, as they occur in the greatest numbers in the United States and parts of Europe. The most southern record is that of *Phyllactinia* at the Beagle Channel, Tierra del Fuego, in the extreme south of South America. One species probably, *Erysiphe cichoracearum*, has been recorded from the tropical island of St. Thomas, off the west coast of Africa; *Phyllactinia corylea* occurs in Guatemala, and *Sphaerotheca pannosa* is reported from the West Indies. As regards the northern limit, *Erysiphe cichoracearum* is found in Lapland, and *Podosphaera oxyacanthae* in Greenland.

As examples of species with a very wide range of distribution may be mentioned *Erysiphe polygoni*, *E. cichoracearum*, *E. graminis*, *Microsphaera alni*, *Podosphaera oxyacanthae*, *Uncinula salicis*, *Sphaerotheca humuli*, and *Phyllactinia corylea*.

Arranging the species as they occur on the main areas of land we have the following table:

	No. of species.	No. of vars.	No. of endemic species.	No. of endemic vars.
Europe,	27	5	9	3
Africa,	7	1	—	—
Asia,	25	3	4	1
Australia and New Zealand,	5	—	—	—
America,	31	7	14	5

We find, therefore, that out of the 49 species and 11 varieties of the *Erysiphaceae*, no less than 27 species and 9 varieties are endemic in the above sense, that is to say, nearly four-sevenths of the species and 9 out of the 11 varieties.

These 27 "endemic" species and 9 varieties are variously further limited in distribution, and it is interesting to note that most of them are confined either to a single species of host-plant or to one genus; *e. g.*, *Erysiphe trina* is known only from California on the single species *Quercus agrifolia*, while *E. tortilis* has a wide European range on *Cornus sanguinea*.

The number of species confined to the Old World is 18, with

4 varieties; to the New World, 14 species with 5 varieties; leaving 17 species and 2 varieties common to both.

In dealing with the features of distribution, however, we must remember that while Europe and the United States have been well-worked for the *Erysiphaceae*, little has yet been done in investigating the family in Africa, Asia and Australia.

An interesting fact is the occurrence in Japan of two species, *Uncinula Clintonii* and *U. polychaeta*, hitherto supposed to be endemic to America. *Sphaerotheca mors-uvae*, widely spread in the United States on species of *Ribes*, appears to be identical with the European species *S. tomentosa* growing on species of *Euphorbia*. *Microsphaera euphorbiae* is not uncommon in the United States on *Euphorbia* and *Astragalus*, and appears in Asia (Turkestan) on *Colutea* and *Astragalus* (*M. coluteae*). *Uncinula necator*, long supposed to be endemic to North America, was discovered in 1892 in France, and has now been found in species of *Actinidia* in Japan. *U. Australiana*, on *Lagerstroemia ovalifolia* in New South Wales, has been sent by Prof. Miyabe, on *L. Indica*, from Japan.

Most of the species of the *Erysiphaceae* show a wide range of variation in their characters, and the description of each species given in the following pages will usually be found to be much wider than that hitherto given by authors.

Examination of a large amount of material has shown conclusively that such characters as the persistence or evanescence of the mycelium, the size of the perithecium, the number of asci, and in many cases the number of spores are far more variable than is generally supposed. On the other hand, just as we find that a classification based on differences in the shape of the appendages divides the family into natural genera, so also we find that frequently the best specific characters are those derived from the appendages. The minute differences in the shape, mode of branching, etc., of the appendages are specifically constant, and usually show far less variation than other characters. It is important to note, however, that the mature condition of the appendages is necessary to show these specific characters; many erroneous descriptions have arisen from the examination of only immature stages.

At the end of the synonomy of each species, a list of exsic-

cati is appended. Only those are quoted which have been personally examined, and unless prefixed by an asterisk, or followed by information as to the source, all the numbers refer to the copies in the Kew Herbarium. Those distinguished by an asterisk are to be found in the Herbarium of the British Museum (Natural History). It is necessary to state exactly what copies have been examined, as—in the case of microscopic fungi especially—different copies of the same numbers in exsiccati may contain different species.

I have not attempted to deal with the described species of *Oidium* in the present work, only mentioning those which are generally admitted to be the conidial stage of known species of the *Erysiphaceae*, as, *e. g.*, *O. Tuckeri* and *Uncinula necator*, *O. monilioides* and *Erysiphe graminis*, etc. In all probability the genus *Oidium* is not autonomous, but consists entirely of conidial forms of the *Erysiphaceae*. About 50 species of *Oidium* have been published; of these six are already known to be the conidial stage of certain species, and over twenty-five of the remaining species grow on plants known to be the hosts of species of the *Erysiphaceae*. I have not included in the descriptions of the species of the *Erysiphaceae* the characters shown in the conidial (*Oidium*) stage. In many species, indeed, this stage has not, at present, been observed. In those cases where only dried material was available, the examination would not have been satisfactory, as in studying the *Oidium*-form living material is necessary in order to arrive at such characters as the number of conidia produced in the chain, the size and shape of the ripe conidium. I hope at some future time to investigate this branch of the subject.

The material examined has been for a large part found in the rich collection of *Erysiphaceae* in the Royal Herbarium, Kew. This collection includes the types of Cooke and Peck's American species, and is especially valuable in containing Berkeley's herbarium. In this occur, besides Berkeley's types, no less than 98 specimens sent by Léveillé to this author (Léveillé's herbarium, M. P. Hariot informs me, was destroyed in 1870 during the Franco-Prussian war); also a number of specimens sent by Castagne, Roberge, etc., and a few examples from Schweinitz' herbarium. For the great facilities afforded me in the use of this collection I am under obligations to the Director of the Royal Gardens, Kew.

Next in importance has been the private collection kindly sent on loan by Prof. F. S. Earle. This contains over 800 excellent specimens of the American *Erysiphaceae*, and is valuable as being the material used by Professor Burrill and Professor Earle in their well-known work on the family (61).

For other American material I am indebted to Prof. W. Trelease, who kindly sent for examination the Herbarium of the Missouri Botanic Gardens; also to Mr. J. B. Ellis, Prof. G. P. Clinton, Prof. L. H. Pammel for the *Erysiphaceae* in the Herbarium of the Iowa State Agricultural College; and to Prof. B. T. Galloway for 150 specimens, many of great interest from the Herbarium of lhe United States Department of Agriculture. These latter are now deposited in the Royal Herbarium, Kew.

Mr. David Griffiths kindly sent me a large collection (over 100 specimens) gathered in South Dakota, Wyoming and Montana; these also are now placed in the Royal Herbarium, Kew.

M. P. Hariot courteously sent me on loan the *Erysiphaceae* contained in the Paris Museum. This collection is of great interest, as it includes Montagne's herbarium, which was examined by Léveillé. In this herbarium are about 25 specimens of Wallroth's (determined by Léveillé; see 214, p. 115); 33 specimens from Léveillé's herbarium; and numerous specimens from Castagne and other authors.

To Prof. W. Tranzschel I am indebted for the loan of a representative collection of Russian *Erysiphaceae*.

Prof. Kingo Miyabe sent a large and extremely valuable collection, accompanied by notes of Japanese specimens. This contained several species not hitherto recorded, from Asia, and included two new species and one new variety. The specimens are deposited in the Royal Herbarium, Kew.

I have to thank Prof. T. M. Fries for the loan of the collection of *Erysiphaceae* in the Upsala Museum, containing those of Fries' herbarium; Prof. L. Jost for the loan of Duby's herbarium, and also specimens from Castagne, Nees von Esenbeck, etc., contained in the herbarium of the University of Strassburg; M. Casimir de Candolle for specimens from De Candolle's herbarium; Prof. E. Fischer for Ott's herbarium in the University of Berne; Prof. E. Baroni for the collection in the Florence Museum (which contains 18 specimens from Léveillé's herbarium); Prof. A. Fischer de Waldheim for the specimens in the herbarium of the St. Petersburg Botanic Gardens; Prof. C. Gobi for those in the herbarium of the University of St. Petersburg, and Prof. J. Eriksson for his collection of Swedish *Erysiphaceae*.

I wish also to thank the authorities at the British Museum (Natural History) for giving me every opportunity of studying the collection of *Erysiphaceae* in this herbarium.

I am also much indebted for specimens, in some case types, to the following botanists: Dr. W. J. Beal, Prof. C. E. Bessey, Abbé Bresadola, Prof. J. Dearness, Prof. C. H. Delogne, Rev. C. H. Demetrio, Prof. A. Macacsy Diete, Prof. P. Gennardius, Prof. B. D. Halsted, Dr. H. W. Harkness, Prof. A. S. Hitchcock, Mr. E. W. D. Holway, Prof. A. Jaczewski, Prof. H. O. Juel, Prof. P. A. Karsten, Rev. F. D. Kelsey, Prof. G. Lagerheim, Prof. D. McAlpine, Prof. T. H. McBride, Prof. G. Massalongo, Prof. E. Palla, M. N. Patouillard, Prof. E. Pâque, Prof. C. H. Peck, Prof. O. Penzig, Dr. H. Rehm, Prof. E. Rostrup, Prof. A. D. Selby, Prof. A. B. Seymour, Rev. A. C. Waghorne and Prof. G. Marshall Woodrow.

I have especially to thank Prof. P. Magnus, Prof. P. A. Saccardo, Mr. P. Sydow, and Prof. L. M. Underwood, not only for several valuable specimens, but also for information given on several points.

To Mr. George Massee for his constant advice and kind assistance in many ways, I wish to express my most sincere thanks.

LIST OF NEW SPECIES AND VARIETIES

Uncinula salicis, var. *Miyabei.*
Uncinula Fraxini.
Uncinula Sengoku.
Microsphaera alni, var. *ludens.*

ERYSIPHACEAE Lév.

Parasitic on living (phanerogamic) plants ; vegetative mycelium white, external to the host-plant, either (*Erysipheae*) forming haustoria in the epidermal cells, or (*Phyllactinieae*) sending special branches for a short distance through the stomata into the intercellular spaces, and from these branches sending haustoria into the surrounding cells ; hyphae thin-walled, septate, much-branched and interwoven ; conidia large, continuous (non-septate), colorless or white, cylindrical, oblong, or barrel-shaped, produced singly or in concatenate chains in basipetal succession on erect, simple, septate, colorless conidiophores ; perithecia arising directly from the mycelium, sessile, at first colorless, then yellow, becoming finally brown or black, membranaceous, indehiscent, globose or globose-depressed, sometimes becoming concave ; walls many-layered, pseudo-parenchymatous, the apical, equatorial or basal cells of the outer wall usually giving rise to definite outgrowths, the appendages, which are either more or less similar to the mycelial hyphae, or quite distinct from them, and variously shaped, simple or branched at the apex, erect or radiating, sometimes colored ; asci one or many, arising from the base of the perithecium, colorless, cylindrical, oblong, ovate or globose, frequently pedicellate, 2–8-spored ; spores continuous (non-septate), colorless, oblong or oval, with obtuse ends, straight or rarely slightly curved ; paraphyses absent.

Sub-family ERYSIPHEAE Palla.

Mycelium wholly external to the tissues of the host-plant ; sending haustoria into the epidermal cells only.

Key to the Genera

1. Ascus solitary. 2.
   Asci several. 3.
2. Appendages of the perithecium basal, sometimes obsolete, not branched in a definite manner at the apex. *Sphaerotheca.*
   Appendages of the perithecium branched at the apex, or if unbranched, arising apically. *Podosphaera.*
3. Appendages of the perithecium nearly always simple (branched in *U. aceris* (see Fig. 87)), uncinate at the apex. *Uncinula.*
   Appendages not uncinate. 4.

4. Appendages branched in a definite manner at the apex, or if unbranched (*M. astragali*) white, assurgent and fasciculate. *Microsphaera.*

Appendages simple, or irregularly branched (no definite apical branching), sometimes obsolete, usually more or less similar to the mycelium, and interwoven with it, very rarely (*E. tortilis*) brown, assurgent and fasciculate. *Erysiphe.*

PODOSPHAERA Kunze, Myk. Heft. 2 : 111. 1823

Perithecia globose, or globose-depressed; ascus solitary, subglobose; spores eight. Appendages equatorial or apical, dark brown or colorless, dichotomously branched at the apex, branches simple and straight, or swollen and knob-shaped; very rarely (*P. leucotricha*) of two kinds, one set apical, brown, rigid, unbranched or rarely 1–2 times dichotomous at the apex, the other set basal short, flexuous, simple or vaguely branched, frequently obsolete. Etym. πούς, *pes*, and σφαῖρα, *sphaera*.—Distrib. Europe, Africa, Asia, North America, and probably Australia.—4 species and 1 variety.

The single ascus separates the genus from all others of the *Erysiphaceae* except *Sphaerotheca*, from which it is at once distinguished by the definite equatorial or apical appendages. *P. leucotricha* which has hitherto been placed in the genus *Sphaerotheca*, and known as *S. mali*, is anomalous among the *Erysipheae* in possessing two kinds of appendages.

Key to the Species of Podosphaera

1. Basal appendages present, apical appendages usually unbranched. 4. *leucotricha.*
Basal appendages absent. 2.

2. Appendages erecto-fasciculate, springing from near the apex of the perithecium. 3.
Appendages more or less spreading and equatorially inserted. 4.

3. Appendages 6–12½ times the diameter of the perithecium, colorless, or occasionally pale brown towards the base. 2. *Schlechtendalii.*
Appendages 1–8 times the diameter of the perithecium, dark brown for more than half their length. 1. *oxyacanthae* var. *tridactyla.*

4. Appendages colorless, or faintly tinged with brown at the base, branches of apex not swollen. 3. *biuncinata.*
Appendages dark-brown for more than half their length, ultimate branches of the apex knob-shaped. 1. *oxyacanthae.*

1. PODOSPHAERA OXYACANTHAE (DC.) de Bary. [Figs. 96, 97, 99–108, 115]

Erysiphe oxyacanthae DC., Mém. Soc. d'Agric. Départ. Seine 10 : 235. 1807; DC. Fl. Fr. 6 : 106. 1815; Duby, Bot. Gall. 2 : 868. 1830; Dur. et Mont. Fl. d'Algér. (Crypt.) 564. 1846–9; Tul. Sel. Fung. Carp. 1 : 202, *pl. 4. f. 10.* 1861.

Alphitomorpha clandestina var. *oxyacanthae* Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 36. 1819; Wallr. in Ann. Wett. Ges. **4**: 242. 1819; Wallr. Fl. Crypt. Germ. **2**: 754. 1833.

Sphaeria myrtillina Schub.; Ficin. Flor. Gegend. Dresd. **2**: 356. 1823.

Podosphaera myrtillina Kze. and Schmidt, Myk. Heft. **2**: 113. *pl. 2. f. 8.* 1823; de Bary, Beitr. Morph. Phys. Pilz. **1**: § XIII. 48. 1870; Sacc. Syll. Fung. **1**: 2. 1882; Wint. in Rabenh. Krypt. Fl. Deutschl. 1^2: 29. 1884; Karst. Act. Soc. Faun. Fl. Fenn. 2^6: 95. 1885; Schroet. in Cohn's Krypt. Fl. Schles. 3^2: 233. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 744. 1896; Oudem. Rév. Champ. Pays-Bas, **2**: 81. 1897.

Erysibe clandestina Lk. in Willd. Sp. Pl. **6**: 103. 1824; Rabenh. Deutschl. Krypt. Fl. **1**: 237. 1844.

Erysiphe clandestina (*oxyacanthae*) Fr. Syst. Myc. **3**: 238. 1829.

E. myrtillina Fr. Syst. Myc. **3**: 247. 1829.

Erysibe myrtillina Rabenh. Deutschl. Krypt. Fl. **1**: 237. 1844.

Podosphaera Kunzei Lév. Ann. Sci. Nat. III. **15**: 135. *pl. 6. f. 6* (*partim*). 1851; Karst. Myc. Fenn. **2**: 198. 1873.

P. clandestina Lév. Ann. Sci. Nat. III. **15**: 36. *pl. 6. f. 5.* 1851; Cooke, Handb. Brit. Fung. **2**: 648. 1871.

P. oxyacanthae (DC.) de Bary, Beitr. Morph. Phys. Pilz. **1**: § XIII. 48. 1870; Sacc. Syll. Fung. **1**: 2. 1882; Wint. in Rabenh. Krypt. Fl. Deutschl. 1^2: 29. 1884; Earle, Bot. Gaz. **12**: 26. 1884 (excl. syn. *P. tridactyla* and *Alphit. tridactyla*; Burr. and Earle, Bull. Ill. State Lab. Nat. Hist. 412. *f. 7* (*syn. excl. partim*). 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 69. 1891; Burr.; Ell. and Everh. N. Amer. Pyren. 21. *pl. 4* (*syn. excl. partim*). 1892; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 234 1893; Jacz. Bull. l'Herb. Boiss. **4**: 743. 1896; Oudem. Rév. Champ. Pays-Bas. **2**: 79. 1897.

P. minor E. C. Howe, Bull. Torr. Club, **5**: 3. 1874; Sacc. Syll. Fung. **9**: 364. 1891.

Microsphaera fulvofulcra Cooke, Grevillea, **5**: 110. 1877; Sacc. Syll. Fung. **1**: 14. 1882, and **9**: 364. 1891.

[?] *Podosphaera clandestina* Lév. var. *ramulicola* Thüm. Bull. Soc. Imp. Nat. Mosc., **56**: 126. 1882.

P. aucupariae Erikss. Fung. par. scand. exsicc. no. 233 (cum diag.) 1886; Sacc. Syll. Fung. **9**: 364. 1891.

P. myrtillina var. *major* Juel. Öfvers. K. Oet. Akad. Förh. **51**: 496. 1895.

Exsicc.: Bri. and Cav. Fung. par. 215; Rab.-Wint. Fung. Eur. 3042, 3241, 3242, 3656; Syd. Myc. March. 1064, 1543, 2227, *3559; Rehm. Ascom. 798, 900; Roumeg. Fung. Gall. Exsicc. 2735, 3736; Westend. Herb. Crypt. Belg. 280, 1057; and 740 sub *Erysiphe penicellata* var. *mespili;* Fckl. Fung. Rhen. 728, 729; Desmaz. Pl. Cr. Fr. ed. 1: ser. 1: 919; and 1305 sub *Erysibe penicellata* var. *mespili*, *ser. 2: 919, *ed. 2: ser. 1; 219; and 705 sub *E. penicellata* var. *mespili;* Ell. and Everh. N. Am. Fung. 55, 55b, 2335; *Ell. and Everh. Fung. Columb. 107; *Sacc. Myc. Ven. 1374; *Seym. and Earle, Econ. Fung. 126, 130, 132, 133, 418, 430; Lib. Pl. Cr. Ard. Fasc. **3**: 278; Karst. Fung. Enun. Exsicc. 277; de Thüm. Fung. Austr. 440, 446; Rab. Fung. Eur. 566; *Wartm. and Schenk, Schweiz. Krypt. 628; *Gandog. Fl. Alger. Exsicc. 1984; *Erikss. Fung. par scand. 32, 135; *Krieg. Fung. Saxon. 72.

Amphigenous, mycelium variable, sometimes persistent in thin patches, at others wholly evanescent; perithecia scattered to more or less densely gregarious in clinging masses, subglobose, 64–90 μ in diameter, cells 10–18 μ wide; appendages spreading, more or less equatorially placed, occasionally springing from nearer the apex, extremely variable in number and length, from 4–30 in number, and from ½–6, or rarely 10 times the diameter of the perithecium, usually unequal in length on the same perithecium, septate, dark brown for more than half their length, usually nearly to the apex, becoming thick-walled throughout, with the lumen more or less obliterated, apex 2–4 times dichotomously branched, branches usually short and equal (sometimes slightly elongated), ultimate branches rounded, swollen, and more or less knob-shaped; ascus broadly obovate, broadly oblong, or subglobose, variable in size, 58–90 × 45–75 μ; spores normally 8, very rarely 6, variable in size, 18–30 × 10–17 μ.

Hosts.—Amelanchier Canadensis, Crataegus Azarolus (272), *C. coccinea, C. Crus-galli, C. Oxyacantha, C. rivularis, C. sanguinea* (350), *C. spathulata, C. subvillosa* (269), *C. tomentosa* and vars. *punctata* and *pyrifolia, Diospyros Virginiana* (299), *Prunus Americana, P. avium, P. Besseyi, P. Cerasus, P. Chicasa* (324), *P. de-*

missa, P. domestica, P. Pennsylvanica (382), *P. Persica* (382), *P. pumila, P. serotina, P. Virginiana, Pyrus Aucuparia, P. coronaria* (97) (137), *P. Cydonia, P. Germanica, P. Malus, Spiraea betulifolia, S. discolor* (159), *S. salicifolia, S. tomentosa, Vaccinium intermedium* (319), *V. Myrtillus, V. uliginosum.*

Distribution.—Europe: Britain, France, Belgium, Netherlands (253), Germany, Switzerland, Italy, Austria-Hungary, Denmark, Norway, Sweden, Finland, Russia. Africa: Algeria. Asia: Siberia (Minussinsk) (350), Japan. North America: United States—Maine (163), Vermont, Massachusetts, Connecticut, New York, New Jersey (53), Virginia, North Carolina, Ohio (71) (324), Michigan, Indiana, Alabama, Illinois, Wisconsin, Missouri, Iowa, South Dakota, Nebraska, Kansas, Montana, Idaho, Utah (363), Wyoming, Colorado, California. Canada—Ontario, New Brunswick, Greenland (300).

Examination of a very large series of specimens has convinced me that the plants hitherto known as *Podosphaera oxyacanthae* and *P. myrtillina* are not specifically distinct. The distinguishing characters relied upon have been these: *P. oxyacanthae*, appendages 8 or more, shorter than or about equaling the diameter of the perithecium; *P. myrtillina*, appendages 4–10, spreading on all sides, or even deflexed, 3 or more times exceeding the diameter of the perithecium. In Europe these two forms, *P. oxyacanthae* on *Crataegus* and *Mespilus*, and *P. myrtillina* on *Vaccinium Myrtillus* and *V. uliginosum*, could perhaps, taken by themselves, be kept distinct as varieties, for the distinctive characters are scarcely of specific value, besides occasionally showing a tendency to fail. On dealing with other material, however, it is seen very clearly that there exists every intermediate link between these two forms.

Let us take first the European form on *Pyrus Aucuparia*, described by Eriksson as a new species. *P. aucupariae*, with the following diagnosis: "Hypophylla. Mycelium evanidum. Perithecia sparsa, sphaeroidea, minuta. Appendices paucae (4–6), diametrum perithecii ter superantes, e parte superiore perithecii radiatim divergentes * * * Mea species *P. aucupariae* differt a *P. oxyacanthae* appendicibus longioribus, a *P. myrtillina* Kze. appendicibus paucis, a *P. tridactyla* (Wallr.) de Bary appendicibus radiatis, ab his utrisque peritheciis hypophyllis."

In Eriksson's own specimens (Fung. par. scand. exsicc. nr. 233), however, the appendages measure 1½ to 2¾ (averaging 2) times the diameter of the perithecium. In the specimen in Rab.-Wint. Fung. Eur. 3241 the appendages are slightly more unequal in length, varying from 1–3 times the diameter of the perithecium. As regards the number of the appendages, this is in Eriksson's *P. aucupariae* 4–8, and in European specimens of *P. myrtillina*, 4–10.

On the whole, *P. aucupariae* connects *P. oxyacanthae* with *P. myrtillina*, and cannot possibly be considered a separate species.

It is, however, in dealing with American specimens that we see how completely "*P. myrtillina*" merges into *P. oxyacanthae*.

The American plant is often erroneously called "*P. tridactyla*" by American mycologists, or *P. Kunzei* (which includes *P. tridactyla*) is quoted wholly as a synonym; other authors, *e. g.*, Earle (110), have supposed that the European *P. myrtillina* might be something different from any of the American forms. As a matter of fact, were the species *P. oxyacanthae* and *P. myrtillina* to be kept distinct most the American forms would fall under the latter, although occurring on other hosts than *Vaccinium*, while *P. oxyacanthae* would have to be confined to certain forms on *Crataegus*, and to the form on *Spiraea*, which has been called *P. minor* E. C. Howe.

A study of American examples on *Crataegus*, *Prunus*, *Pyrus*, *Spiraea*, etc., shows conclusively, however, that only a single species exists, but one which is extremely variable in the length and number of its appendages. Earle has some interesting remarks in his "Notes on the North American Forms of *Podosphaera*" (110) on the subject of this variability, and this author's conclusion that all the American forms must be included under the single species *P. oxyacanthae* is undoubtedly correct. A specimen in Professor Earle's herbarium shows clearly how completely the long- and short-appendaged forms are connected. This specimen is labeled "on *Crataegus*, Deland, Illinois, Sept., 1889. A. B. Seymour." Many of the perithecia are identical in the few short appendages with those of the European *P. oxyacanthae* on *Crataegus Oxyacantha;* other perithecia show, quite gradually, an in-

crease in both the number and length of the appendages, until they cannot be separated from the more common long-appendaged American form. *P. minor* Howe (*Microsphaera fulvofulcra* Cooke) on *Spiraea tomentosa* also shows much the same variation in the length of the appendages.

These short-appendaged forms show the range of variation of *P. oxyacanthae* in one direction, in the other we meet with a very long "appendaged form on *Vaccinium uliginosum*, which has been described as '*P. myrtillina* var. *major* Juel.'" Professor Juel has kindly sent me a specimen (now in the Kew Herbarium) of this form. In this specimen I find that contiguous perithecia have appendages varying from 2½ to 10 times the diameter of the perithecium. I have seen exactly the same form—with the appendages varying in length from 6–10 times the diameter of the perithecium—in Russian specimens in Professor Tranzschel's herbarium. As this great variation occurs in perithecia on the same leaf, it is obviously impossible to treat the length of the appendages as a character of diagnostic value, and in other respects the form shows no differences.

In conclusion, it appears then that we must allow to the present species—*P. oxyacanthae*—a range of variation in the length of its appendages of from less than the diameter of the perithecium to ten times exceeding it. The existence of a perfect series of connecting links justifies this treatment, as does also the fact that similar variation in the same characters is found in other species. In the var. *tridactyla* of the present species the appendages vary from 1–8 times the diameter of the perithecium. In the series of forms of *Microsphaera alni*, the one long known as "*M. Hedwigii*" corresponds exactly in the short, few appendages with the form of *P. oxyacanthae* on *Crataegus Oxyacantha* and *Mespilus*, and mycologists now admit that "*M. Hedwigii*" must be united with the longer appendaged forms of *M. alni*.

In some examples of American *P. oxyacanthae* on *Crataegus* the perithecia form densely matted patches about the midrib of the leaf. Perhaps the plant described by Thümen (350) as *Podosphaera clandestina* var. *ramulicola* is a similar form. The following description is given: "Periitheciis dense aggregatis, numerosissimis, pulviniformibus; mycelio candido, non evanido; ascis sporisque

typicis. In ramulis vivis *Crataegi sanguineae* Pall. in sylvis pr. Minussinsk.

P. oxyacanthae is known in America as the "Cherry Powdery Mildew"; also as the "Apple Powdery Mildew," although it is possible that under the latter name *P. leucotricha* is sometimes intended.

Pammel (266 and 267) describing the "Cherry Powdery Mildew" states that the disease can be treated successfully with Bordeaux mixture and ammoniacal carbonate of copper.

Galloway (136) speaking of an "Apple Powdery Mildew," which was identified as the present species, states that it causes the most serious injury to fruit trees, especially to the young stock of nurseries. In one case, owing to the presence of the mildew, of some stocks budded, only about two thirds of the buds took. Full details are here given of the preparation and application of the ammoniacal carbonate of copper, which was found perfectly successful as a fungicide. The interesting statement is made that "*P. oxyacanthae* probably winters in a mycelial stage."

Benson (24) attributes a disease on apple trees, widely spread over the colony of New South Wales, to "*P. Kunzei* Lév.," and recommends the diseased trees, when in bud, to be sprayed with Bordeaux mixture, followed with a dressing of ammonio-carbonate of copper. As the fungus was, apparently, observed only in the conidial stage, the identification with the present species remains doubtful.

Waite (382) states of the present species that "young cherry trees are the chief sufferers from its attacks, but it also does considerable harm to the peach and to young apple trees in the nursery, and occasionally seriously injures the quince." It is also noted that the most destructive form of the fungus usually bears but a few perithecia, and often fails to produce any before frost puts an end to the season's growth. Spraying with a mixture of half an ounce of potassium sulphide in a gallon of water is recommended.

P. oxyacanthae sometimes attacks *Crataegus Oxyacantha* so severely that it kills the plant. Eriksson (119) records such cases from the neighborhood of Stockholm, where young trees up to 4 feet high were destroyed. It is also stated that the fungus frequently produces no perithecia on this host.

Rose (299) records the occurrence of *P. oxyacanthae* on the Persimmon (*Diospyros Virginiana*), and remarks that all the asci examined "contained 9 spores, differing in this respect from any of the species of *Podosphaera*.

Var. TRIDACTYLA (Wallr.) [Figs. 109–114]

Alphitomorpha tridactyla Wallr. Fl. Crypt. Germ. **2**: 753. 1833.

A. (*Erysiphe*) *Brayana* Doith, Flora, **21**: 475. *pl. 1. f. 7.* 1838.

Erysibe tridactyla Rabenh. Deutschl. Krypt. Fl. **1**: 237. 1844.

E. Brayana Rabenh. Deutschl. Krypt. Fl. **1**: 237. 1844.

Erysibe tridactyla Desmaz. Ann. Sci. Nat. III. **3**: 361. 1845.

Podosphaera Kunzei Lév. Ann. Sci. Nat. III. **15**: 135 (partim). 1851; Cooke, Handb. Brit. Fung. **2**: 647 (excl. fig.). 1871.

Erysiphe tridactyla Tul. Sel. Fung. Carp. **1**: 201. *pl. 4. f. 11–13.* 1861.

Podosphaera tridactyla (Wallr.) de Bary, Beitr. Morph. Phys. Pilz. **1**: § XIII. 48. 1870; Sacc. Syll. Fung. **1**: 2. 1882; Win. in Rabenh. Krypt. Fl. Deutschl. **1²**: 28. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 95. 1885; Schroet. in Cohn's Krypt. Fl. Schles. **3**: 233. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 744. 1896; Ouden. Rév. Champ. Pays-Bas. **2**: 81. 1897.

Exsicc.: Sacc. Myc. Ven. 783; and 616 sub *Uncinula Wallrothii;* de Thüm. Fung. Austr. 122, 439 and 463 sub *U. Wallrothii;* Rehm. Ascom. 850; Rab. Fung. Eur. 565, 565b, 2412; Rab. Herb. myc. ed. 2, 475; and 487 sub *Erysibe adunca* var. *Padi;* Vize. Fung. Brit. 195; Fckl. Fung. Rhen. 726, 727; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 1514,* 2194 and *ed. 2, ser. 1, 1014, 844; Syd. Myc. March. 1141; Roumeg. Fung. Gall. exsicc. 1498; de Thüm. Myc. univ. 159; *Erbar. Critt. Ital. ser. 2, 494; Brit. & Cav. Fung. par. 292; *Erikss. Fung. par. scand. 136.

Amphigenous; mycelium usually evanescent, rarely subpersistent; perithecia scattered to more or less densely gregarious, subglobose, 70–105 μ in diameter, cells 10–15 μ wide; appendages 2–8, usually about 4, 1–8 times the diameter of the perithecium, usually unequal in length on the same perithecium, springing in a cluster from the apex of the perithecium, more or less erect, when long often fasciculate, septate, dark brown for more than half their

length, apex 3–5 (rarely 6) times dichotomously branched, primary branches (and rarely the secondary) usually more or less elongated, and sometimes slightly recurved, ultimate branches rounded, swollen and more or less knob-shaped; ascus globose or subglobose, 60–78 × 60–70; spores 8, 20–30 × 13–15 μ, sometimes slightly curved.

Hosts.—*Prunus Armeniaca, P. communis, P. domestica, P. insititia, P. Padus, P. spinosa, Spiraea Douglasii* [*Pyrus Aucaparia* (319)].

Distribution.—Europe: Britain, France, Belgium (46, 209). Netherlands (263), Germany, Switzerland (176), Italy, Austria-Hungary, Denmark, Norway, Sweden, Russia. Asia: Japan. North America: United States, Washington.

The apical insertion of the more or less erect, often fasciculate appendages, together with a marked tendency for the apex of the appendages to become more elaborately divided are the characteristic features of the present plant. The apex of the appendages, besides being more branched than in the type, frequently develops long primary branches; this latter character is not, however, absolutely confined to the present variety, as it occurs rarely in examples of *P. oxyacanthae*. Considering European specimens alone, it might be contended that these characters are constant and important enough to give a specific rank. Occasionally, however, amongst these, examples occur in which a slight spreading tendency is shown in the appendages. This tendency is more marked in the American example, which consequently forms a link with *P. oxyacanthae*.

Without exception all the American plants labelled "*P. Kunzei*" (the name under which Léveillé united "*P. tridactyla*" and "*P. myrtillina*") that I have seen, belong to *P. oxyacanthae*, and the only specimen which belongs to the present variety is one sent to me from the herbarium of the U. S. Dept. of Agric. named "*Sphaerotheca humuli* (DC.) Burr. on *Spiraea Douglasii*, Seattle, Washington, Oct., 1891 (A. M. Parker)." In this specimen (now in the Kew Herbarium) the long, more or less erect appendages springing from near the apex of the perithecium refer the plant to the var. *tridactyla*, and are quite different to the appendages of the form of *P. oxyacanthae* which occurs commonly on American species of *Spiraea*. Nevertheless, in some perithecia

the appendages here and there have a tendency to spread, and thus show characters connecting *P. oxyacanthae* with its var. *tridactyla.*

The published records of "*P. tridactyla*" (Wallr.) from America (53) (249) (366), etc., almost certainly all belong to *P. oxyacanthae*, as the former name has been in error, commonly used by American mycologists as a synonym of the latter species.

The Japanese plant occurs on *Prunus communis*, and was sent to me by Professor Miyabe. The appendages are few, short, and fasciculately erect, with a large very widely branched apex.

Schroeter's (319) record of the occurrence of the present plant on *Pyrus Aucuparia* probably refers to *P. oxyacanthae.*

McAlpine (225) records "*P. tridactyla* de Bary" on "young leaves and shoots of Apple," from Victoria and New South Wales, but very probably this record rests merely on the occurrence of an *Oidium* on this host, and the fungus may prove to belong to *P. leucotricha;* the Apple is not known as a host-plant for the var. *tridactyla.*

In the present variety the length of the appendages varies from 1–8 times the diameter of the perithecium, and there is also great variation in the manner of the branching of the apex (see Figs. 109–113).

2. P. SCHLECHTENDALII Lév. [Figs. 118, 123]

P. Schlechtendalii Lév. Ann. Sci. Nat. III. **15**: 29. *pl. 6. f. 7.* 1851; Sacc. Syll. Fung. **1**: 3. 1882.

Hypophyllous; mycelium evanescent; perithecia scattered, subglobose, 78–90 μ in diameter, cells 10–15 μ wide; appendages 5–12, unequal in length, 6–12½ times the diameter of the perithecium, erecto-fasciculate, springing from the apex of the perithecium, and forming a long flaccid, somewhat flexuous bundle, which is more or less entangled in the hairs of the leaf, septate, colorless above, occasionally pale brown towards the base, apex 2, very rarely 3 times dichotomously branched, end of ultimate branches more or less thickened, primary and secondary branches usually recurved; ascus subglobose, 76–84 × 68–74 μ; spores 8, 23–28 × 13–15 μ, sometimes slightly curved.

Hosts.—*Salix alba* (214), *S. viminalis.*

Distribution.—Europe: France.

There is a good specimen of this extremely interesting species

in Berkeley's Herbarium at Kew, sent to that author by Léveillé himself. *P. Schlechtendalii* has apparently disappeared since its discovery in 1851; I have seen no other example than the one mentioned above, and it is very probable that the Kew specimen is the only one in existence.

Quite lately (1897) Speschnew (338) has recorded *P. Schlechtendalii* as occurring, rarely, on the willows of the islands of R. Alazan, Transcaucasia. If the identification is correct, the reappearance of this long-lost species in so distant a locality is very interesting.

Léveillé (214, p. 137), found the original species at Neuilly, near Paris, on the leaves of *Salix alba* and *S. viminalis*, and in his description makes the following observations: "Cette espèce, qui n'a pas encore été signalée, est une des plus remarquables et des plus faciles à reconnaître. Ses appendicules, au nombre de huit ou dix, ont de dix à onze fois la longueur du diamètre des conceptacles, et leur extrémité présente des rameaux filiforme contournés en vrille. Cette extrémité est assez difficile à voir; il faut beaucoup de précautions pour la détacher, sans la briser, des poils qui recouvrent la face inférieure des feuilles."

3. P. BIUNCINATA Cooke & Peck [Fig. 98]

P. biuncinata Cooke & Peck, Journ. of Bot. **1**: 11. 1872; Peck, Reg. Rep. **25**: 94. 1873; Sacc. Syll. Fung. **1**: 3. 1882; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 69. 1891; Burr. in Ell. and Everh. N. Am. Pyren. 22. 1892.

Exsicc.: de Thüm. Myc. Univ. 2050; Ellis, N. Amer. Fung. 1326; Rab.-Wint. Fung. Eur. 3540; *Seym. and Earle, Econ. Fung. 135; *Ell. and Everh. Fung. Columb. 509.

Amphigenous; mycelium persistent, arachnoid and effused, or evanescent; perithecia scattered, or often densely gregarious, subglobose, 55–72 μ in diameter; appendages 4–15, equatorially placed and spreading, 3–5 times as long as the diameter of the perithecium, straight or slightly flexuous, aseptate, smooth, usually colorless throughout, sometimes with a faint tinge of brown at the base, narrow (4–5 μ wide), thin-walled above, becoming thick-walled and refractive at base, apex once or rarely twice dichotomously branched, primary branches long or short, more or less recurved; secondary branches, when present, shorter,

tips of ultimate branches straight, blunt; ascus globose, or subglobose, with a minute stalk, 45–50 × 40–48 μ; spores 8, 20–24 × 11–13 μ.

"This is a very distinct species. The branches at the tips of the appendages are slightly curved, and diverge nearly at right angles to the appendage. When mature, the plants often become collected in entangled masses, giving the leaf the appearance of being coated with dusty cobwebs" (Peck, Reg. Rep. **25**: 95).

Host.—Hamamelis Virginiana.

Distribution.—North America: United States—Massachusetts, Connecticut, New York, North Carolina, Ohio (71), Indiana, Alabama (12), Illinois, Wisconsin. Canada—Ontario.

P. biuncinata is known at once by the long spreading colorless appendages. The apex of the appendages is usually only once forked, rarely the primary branches are again divided (see fig. 98). I have once observed two asci in the same perithecium.

4. P. LEUCOTRICHA (Ell. and Everh.) [Figs. 119–122]

Sphaerotheca leucotricha Ell. and Everh. Journ. Mycol. **4**: 58. 1888; Sacc. Syll. Fung. **9**: 365. 1891.

S. mali Burr. in Ell. and Everh. N. Amer. Pyren. 6 (excl. syn. *Erysiphe mali* Duby). 1892; Magnus, Bericht. Deutsch. Bot. Gesell. **16**: 333. *pl. 21.* 1898; Grout, Bull. Torr. Club, **26**: 374. *pl. 364.* 1899.

Albigo leucotricha (Ell. and Everh.) Kuntze, Revis. Gen. Plant. **3**²: 442. 1892.

EXSICC.: *Syd. Myc. March. 3161, sub *S. castagnei* Lév.; Warlich, Parasit. Pilz. 17, 18, sub *S. castagnei* Lév. (in Herb. Hort. Imp. Petropol.).

Mycelium amphigenous, persistent, thin, effused; perithecia densely gregarious, rarely more or less scattered, 75–96 μ in diameter, subglobose or sometimes slightly pyriform, cells 10–16 μ wide, usually 10 μ; appendages of two kinds, one set springing from the apex of the perithecium, the other inserted basally; apical appendages 3–11 in number, usually 3–5, more or less widely spreading, or erecto-fasciculate, 4–7 times the diameter of the perithecium, septate when young, becoming thick-walled with the lumen more or less obliterated, colored dark brown in the lower half, paler towards the tip, apex undivided and blunt, or rarely once or twice dichotomously divided; basal appendages

sometimes nearly obsolete, sometimes well-developed, short, more or less tortuous, pale brown, simple or irregularly branched; ascus oblong to subglobose, 55–70 × 44–50 μ; spores 22–26 × 12–14 μ, crowded in the ascus.

Hosts.—*Pyrus Malus, P. Sieboldi.*

Distribution.—Europe: Germany, Austria-Hungary (Tyrol), Russia (Tauria). Asia: Japan. North America: United States: Vermont, Wisconsin, Mississippi (60), Iowa, Missouri (117), Kansas (154).

In its characteristic form this species, when in fruit, produces matted patches on the young stems of the apple, occasionally occurring on the petioles or very rarely scattered on the leaves. The patches of densely compacted perithecia among the persistent mycelium, from their long, more or less erect rigid appendages, give a densely hirsute appearance to the infected stem. These apical appendages are, however, apparently very deciduous.

The present species was first described in 1888 as *Sphaerotheca leucotricha* by Ellis and Everhart (117). Burrill (60), in 1892 changed the name to *S. mali* (Duby), identifying it with the *Erysiphe mali* of that author. Burrill remarked as follows: "This exceedingly interesting species has not been well separated from *Podosphaera oxyacanthae* which occurs on the same host, and to casual observation has much the same appearance. In our species the tips of the large appendages are occasionally forked (once or even slightly twice), which again may have been confusing. But these vague stiff branches are totally unlike the dichotomous divisions of *Podosphaera*, and otherwise the species are very distinct. The tuft of short, interwoven, rudimentary appendages, like a dense cluster of short roots, is a very characteristic mark." Duby's *Erysiphe mali* Bot. Gall. **2**: 869, however, is not the present species but is *Phyllactinia corylea*, as an examination of the type in Duby's herbarium at the University of Strasburg showed.

From the study of many examples of the present plant, including authentic specimens kindly sent by Professor Ellis, I am led to refer the fungus to the genus *Podosphaera* rather than to *Sphaerotheca*. The apical appendages are quite different from anything found in the genus *Sphaerotheca*, while similar in structure and insertion to those of *Podosphaera oxyacanthae* var. *tri-*

dactyla, to which plant I consider *P. leucotricha* to be most nearly allied. From all known species of *Erysipheae* the present plant differs in possessing two kinds of appendages, and suggests, I think, the manner in which *Sphaerotheca* may have arisen from some such genus as *Podosphaera*. In the present species there are signs that the more specialized apical appendages are beginning to die out, as is shown by the fact that these only rarely develop to the stage of forking, commonly remaining undivided and blunt at the apex. On the other hand, the *Sphaerotheca*-like basal appendages have already appeared. These are sometimes obsolete, sometimes well developed and densely clustered.

P. leucotricha was known only from North America, until Magnus (228) recently reported it from the Tyrol. It appears certain, however, that it is really quite common in parts of Europe in the *Oidium* stage on the young stems and buds of apple, but that it has been passed over on account of the fact that it only very rarely produces perithecia. Professor Magnus kindly sent me his specimens from the Tyrol for examination, and I found them to agree perfectly with American examples.

Quite similar to the Tyrolese specimens are Russian ones which I have found contained in the Herbarium of St. Petersburg, under the name of *Sphaerotheca castagnei* (W. Wahrlich, Parasit, Pilze, 17 and 18); this is also the case with the specimens (similarly named) from Germany issued in Syd. Myc. March. no. 3161.

P. leucotricha has also occurred among the Japanese *Erysiphaceae* sent to me by Prof. Miyabe. This example (now in the Kew Herbarium) is growing on *Pyrus Toringo* (*P. Sieboldi*), and is without doubt the same as the American and European species. The apical appendages are here sometimes very poorly developed, or even apparently absent, sometimes long and characteristic; the curious root-like basal appendages are developed prominently. The perithecia are clustered in the characteristic manner, forming blackish masses on the persistent white powdery mycelium. This occurrence, besides adding Asia to the range of distribution, gives a new host-plant for the species.

P. leucotricha is so prevalent in some parts as to form a disease. Pammel (267) says "In some parts of the United States apple seedlings are seriously affected with this disease. It rarely affects

old trees but is especially common on "suckers," coming up around large trees in the orchard and nursery." Ammoniacal carbonate of copper and Bordeaux mixture were found efficacious as fungicides. It is probable that the common American "apple powdery mildew" disease, generally attributed to *P. oxyacanthae*, is in many cases caused by the present species.

Sorauer has given an account in Hedwigia (332) of a mildew disease of apple trees, in which the fungus is identified as "*Sphaerotheca Castagnei* Lév. f. *mali*." Professor Sorauer kindly sent me a series of microscopical slides of this mildew, and in these the characteristic perithecia of the present species are clearly to be seen. The thick-walled septate rigid appendages are wrongly described in Hedwigia as being basal. They are in reality (as the specimens show) apical; most of the perithecia possess also the characteristic root-like basal appendages. Professor Sorauer (*loc. cit.*) gives some interesting details of the manner in which the fungus attacks the apple trees, and mentions that, in severe cases, the weaker shoots of the tree are killed. It is also stated that a hibernation of the mycelium takes place on the young shoots.

Cobb (73, p. 279) gives an account of a disease prevalent in Australia, called the "powdery mildew of the apple." No perithecia were found by the author, although the fungus is referred to "*P. Kunzei* Lév." It is, however, more probable from the description that *P. leucotricha* is the cause of the disease. Some interesting information is given, as follows: "No account of the diseases of the apple would be complete without mention of the powdery mildew which does so much damage to young apple-trees (especially seedlings) in nurseries. In Australia the disease is by no means confined to nurseries. I have repeatedly had examples sent in from trees two, three, and four years old; in fact, orchardists send in this disease oftener than any other apple disease, scab excepted; so there can be no doubt that it is a plague to them as well as to nurserymen. * * * The leaves near the ends of the branches are the first to go." Spraying with ammonio-carbonate of copper or Eau Céleste is recommended.

Although *P. leucotricha* is at present supposed to be a rare species, it will very probably prove to be widely distributed and common, and has most likely been hitherto passed over by my-

cologists on account of the peculiarity it possesses of very rarely forming perithecial fruit; in its conidial stage it is probably frequently recorded as *P. oxyacanthae*. It will probably be found to occur in Britain, although I have not at present seen an example. It is very probable that what has been known as *Oidium farinosum* Cooke will prove to be the conidial stage of the present species. This *Oidium* is not uncommon on apples in some parts of England, and attacks especially the young leaves and leaf-buds, causing the leaves to fall prematurely and hindering or completely stopping the formation of young wood.

A good account and figure of *P. leucotricha* has been recently given by Grout (154) in the Bull. Torr. Club.

SPHAEROTHECA Lév. Ann. Sci. Nat. III. 15: 138. 1851*

Perithecia subglobose, ascus solitary, 8-spored. Appendages floccose, brown or colorless, spreading horizontally and often in-

* Kuntze (207) has recently stated that the name *Sphaerotheca* for the present genus must give way to the earlier name *Albigo*. Kuntze remarks: *Albigo* Steud. "Ehrh." Nomencl. (1824) Crypt. 52 and 54 = *Sphaerotheca* Lév. 1851. Es ist *Albigo humuli* Steud. "Ehrh." = *Albigo macularis* Streinz. Nom. 270. "Ehrh. in sched." = *Alphitomorpha macularis humuli* Wallr. * * * *Albigo* ist zwar ein nomen seminudum, scheint mir aber sicher recognoscirbar." Kuntze then proceeds to transfer to *Albigo* all the species of *Sphaerotheca* mentioned in Saccardo's Sylloge. Magnus (232) has criticised the above statements and expressed the opinion that the name *Albigo* has no claim to be adopted, but has suggested that perhaps the name *Sphaerotheca macularis* (Ehrh.) ought to be employed in the place of *S. humuli* DC.

Neither Kuntze nor Magnus, however, reached the origin of the name *Albigo*. This is found in Ehrhart's Beitr. zur Naturkunde, 7: 84. 1792, where the following description is given: "Mehlthau (*Albigo* mihi zum Unterschied von der Rubigine (Rost, Rötheln, Karfaugel) * * * ist ein weisslichtes, staubartiges Wesen, welches gewöhnlich auf der untern Seite der Blätter des Hopfens, der Erbsen, und mehreres Pflanzen, sitzet, und zur Zeit der Réife hin und wieder mit kleinen, schwarzen Kügelchen bestreuet ist." Ehrhart concludes by saying that this substance is really a fungus—"und zwar der *Mucor Erysiphe* Linn. ist. Wer ihn aus dieser Beschreibung nicht kennen lernen kann, der schlage meine Plantas cryptogamas, n. 100, nach, wo er getrocknete Exemplare davon finden wird." M. P. Sydow kindly consulted for me the copy of Ehrhart's Exsiccati in the Berlin Museum, and informs me that the specimen No. 100 is labelled merely *Mucor Erysiphe* Linn. No mention of *Albigo* occurs, nor is any diagnosis given. As Ehrhart's remarks quoted above show, this author used the word *Albigo* in a quite general sense for all mildews, and we find it nowhere defined as a genus. Consequently, there are no grounds for substituting this name for Léveille's *Sphaerotheca*. The name "*S. macularis* (Ehrh.)" which Magnus has supposed should possibly supercede that of *humuli* DC. for the Hop Mildew, has also no claim to be recognized.

terwoven with the mycelium, simple or vaguely branched; frequently obsolete. Etym. *σφαιρα, sphaera*, and *θηκη, theca*.

Distribution.—Europe, Africa, Asia, Australia, North and South America—5 species and 1 variety.

The single ascus and floccose appendages, more or less resembling the mycelial hyphae, separate *Sphaerotheca* from all other genera. The most interesting features shown are the production of special thick-walled, interlaced hyphae from the vegetative mycelium, forming a persistent pannose covering for the more or less immersed perithecia (*S. pannosa, S. lanestris*, etc.) and the complete separation of the inner wall of the perithecium from the outer, which takes place is some species (*S. phytoptophila, S. lanestris*). *S. phytoptophila* only occurs, apparently, in association with a species of gall-mite (*Phytoptus*).

Key to the Species of Sphaerotheca

1. Mycelium persistent, thick, pannose, forming dense patches composed of special hyphae, in which the perithecia are more or less immersed. 2.
   Mycelium without these characters. 4.

2. Persistent mycelium usually satiny and shining, white, sometimes becoming gray or pale brown. 2. *pannosa.*
   Persistent mycelium dark brown. 3.

3. Inner wall of perithecium separating from the outer, hyphae of persistent mycelium very tortuous. 4. *lanestris.*
   Inner wall not separating, hyphae straighter. 3. *mors-uvae.*

4. Perithecia 60–78 μ in diameter, ascus 60–75 $\times$ 42–50 μ, inner wall of perithecium separating from the outer. 5. *phytoptophila.*
   Perithecia 50–120 μ in diameter, ascus 45–90 $\times$ 50–72 μ; inner wall scarcely separating. 5.

5. Cells of outer wall of perithecium 10–20 μ wide, averaging 15 μ. 1. *humuli.*
   Cells 20–30 (rarely 40) μ wide, averaging 25 μ. 1. *humuli*, var. *fuliginea.*

1. SPHAEROTHECA HUMULI (DC.) Burr. [Figs. 116, 117]

Mucor Erysiphe Linn. Sp. Pl. **2**: 1186 (partim). 1753.

Sclerotium Erysiphe Pers. Obs. Myc. **1**: 13 (partim). 1796; Pers. Syn. Fung. 124 (partim). 1801.

Erysiphe humuli DC. Fl. Fr. **6**: 106. 1815; Duby, Bot. Gall. **2**: 868. 1830; Tul. Sel. Fung. Carp. **1**: 211. *pl. 4. f. 9.* 1861.

E. sanguisorbae DC. Fl. Fr. **6**: 108. 1815; Duby, Bot. Gall. **2**: 868. 1830.

Alphitomorpha macularis Wallr. Berl. Ges. Nat. Freund. Verh. 1 : 35 (partim). 1819; Wallr. Fl. Crypt. Germ. 2 : 756. 1833.

A. clandestina, var. *alchemillae* Wallr. Berl. Ges. Nat. Freund. Verh. 1 : 36. 1819.

A. ferruginea Schlecht. Berl. Ges. Nat. Freund. Verh. 1 : 47. 1819.

A. aphanis Wallr. Ann. Wett. Ges. 4 : 242. 1819.

A. humuli Wallr. Ann. Wett. Ges. 4 : 243. 1819.

A. epilobii Wallr. Ann. Wett. Ges. 4 : 243. 1819.

Erysibe macularis, var. *humuli* Ficin. & Schub. Fl. Gegend. Dresd. 2 : 304. 1823.

E. macularis Schlecht. Fl. Berol. 2 : 168. 1824. Rabenh. Deutschl. Krypt. Fl. 1 : 231. 1844.

E. humuli Lk.; Willd. Sp. Pl. 6 : 101. 1824.

E. epilobii Lk.; Willd. Sp. Pl. 6 : 102. 1824.

E. fuliginea Lk.; Willd. Sp. Pl. 6 : 102 (partim). 1824; Rabenh. Deutschl. Krypt. Fl. 1 : 230 (partim). 1844.

E. ferruginea (*poterii*) Lk.; Willd. Sp. Pl. 6 : 103. 1824.

E. aphanis Lk.; Willd. Sp. Pl. 6 : 104. 1824.

Erysiphe alchemillae Grev. Fl. Edin. 460. 1824.

E. macularis Fr. Syst. Myc. 3 : 237. 1829.

E. fuliginea Fr. Syst. Myc. 3 : 238 (partim). 1829.

E. ferruginea Fr. Syst. Myc. 3 : 238. 1829.

E. communis Fr. Syst. Myc. 3 : 239 (partim). 1829.

E. poterii Duby, Bot. Gall. 2 : 868. 1830.

E. alchemillae Duby, Bot. Gall. 2 : 870. 1830.

Erysibe alchemillae Desmaz. Pl. Cr. Fr. ser. 1, no. 517. 1831.

Alphitomorpha horridula, var. *spiraeacearum* and *dryadearum* Wallr. Fl. Crypt. Germ. 2 : 756. 1833.

Erysibe potentillae Lib. Pl. Crypt. Ard. fasc. 3, no. 279. 1834.

E. horridula Rabenh. Deutschl. Krypt. Fl. 1 : 235 (partim). 1844.

Erysiphe crodii Dur. & Mont. Fl. d'Algér. (Crypt.) 567 (excl. syn.). 1846–9; Mont. Syll. Crypt. 253. 1856; Sacc. Syll. Fung. 1 : 20. 1882.

E. glomerata Mér. Addit. Rev. Fl. Par. 497. 1847.

Sphaerotheca Castagnei Lév. Ann. Sci. Nat. III. 15 : 139. *pl. 6. f. 9, 10, 10'* (partim). 1851; Cooke, Micr. Fung. 218. *pl. 11. f.*

216 (partim). 1865; Cooke, Handb. Brit. Fung. **2**: 645. *f. 312* (partim). 1871; Karst. Myc. Fenn. **2**: 197 (syn. excl. partim). 1873; Sacc. Syll. Fung. **1**: 4 (partim). 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 27 (partim). 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 94 (partim). 1885; Jacz. Bull. l'Herb. Boiss. **4**: 725 (partim). 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 83 (partim). 1897.

Erysibe horridula, var. *ulmariae* Desmaz. Pl. Cr. Fr. ed. 1, n. 2196; ed. 2, n. 1846, and Ann. Sci. Nat. III. **18**: 370. 1852.

Erysiphe dipsacearum Tul. Sel. Fung. Carp. **1**: 210. *pl. 4. f. 4–8* (*syn. excl. partim*). 1861.

Podosphaera epilobii De Bary, Beitr. Morph. Phys. Pilze **1**: § xiii. 48. 1870.

Sphaerotheca pruinosa Cooke & Peck, Journ. of Bot. **1**: 11. 1872; Peck, Reg. Rep. **25**: 94. 1873; Sacc. Syll. Fung. **1**: 3. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 399. 1887; Burr.; Ell. & Everh. N. Amer. Pyren. 5: 1892.

S. Niesslii Thuem. Verh. k. k. zool.-bot. Gesell. Wien, **29**: 524. 1880; Sacc. Syll. Fung. **1**: 4. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 28. 1884.

S. epilobii (Lk.) Sacc. Syll. Fung. **1**: 4. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 27. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 95. 1885; Burr.; Ell. and Everh. N. Amer. Pyren. 8. 1892; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 232. 1893.

S. fugax Penz. and Sacc. Att. R. Instit. Ven. VI. **2**: 10. 1884; Sacc. Syll. Fung. Addit. ad vol. I–IV: 1. 1886; and **9**: 365. 1891.

S. humuli (DC.) Burr. Bull. Ill. State Lab. Nat. Hist. **2**: 400. 1887; Burr; Ell. and Everh. N. Amer. Pyren. 5. 1892.

Albigo humuli "Ehrh." Steud., Kuntze, Revis. Gen. Plant. **3**^{2}: 442. 1892.

A. epilobii (Lk.) Kuntze, Revis. Gen. Plant. **3**^{2}: 442. 1892.

A. fugax (Penz. and Sacc.) Kuntze, Revis. Gen. Plant. **3**^{2}: 442. 1892.

A. Niesslii (Thuem.) Kuntze, Revis. Gen. Plant. **3**^{2}: 442. 1892.

A. pruinosa (Cke. and Peck) Kuntze, Revis. Gen. Plant. **3**^{2}: 442. 1892.

S. humuli (DC.) Schroet.; Cohn's Krypt. Fl. Schles. 3: 231 (partim). 1893.

EXSICC.: Klotzsch, Herb. Myc. 63, and spec. sub *Erysiphe communis*, var. *geranii*; Rehm. Ascom. 250; Cooke, Fung. Brit. Exsicc. 91; ed. sec. 590; Roumig. Fung. select. exsicc. 4840, 5622; Speg. Dec. Myc. Ital. 40; Rab. Fung. Eur. 557, 558, 1047, 1049, and 1430 sub *E. communis;* Syd. Myc. March. 1075, 2660, 2661, *3724, *4245; Sacc. Myc. Ven. 627, 628; de Thuem. Fung. Austr. 235, 443, 654, 755, and 1239 sub *E. communis;* de Thuem. Myc. univ. 960, 1540, and 2056 sub *E. lamprocarpa;* Fl. Exsicc. Austro-Hungar. 380; Westend. Herb. Crypt. Belg. 407, 829; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 165, 517, 1113, 1302, 1303, and 2196 sub *Erysibe horridula* ?, *ed. 2, ser. 1, 513, 702, 703, 812, 1846; Fckl. Fung. Rhen. 711, 712, 713, 718, 721, 2234, 2235; Oudem. Fung. Neerl. Exsicc. 72; Rab. Herb. Myc. ed. 2, 460, 468, and 481 sub *Erysibe horridula;* Roumeg. Fung. Gall. Exsicc. 640, and 3517, 3742, sub *E. communis;* Ayres, Myc. Brit.; Jack, Lein. and Stitzenb. Krypt. Bad. 633, 827; Lib. Pl. Crypt. Ard. fasc. 3, 279; and fasc. 4, 381; Rab.-Wint. Fung. Eur. 3041; Berk. Brit. Fung. 313, sub *Erysiphe communis;* Karst, Fung. Fenn. Exsicc. 278; Vize Fung. Brit. 91, sub *Sphaerotheca pannosa;* Rab.-Wint.-Patzsch. Fung. Eur. 3856; Erbar. Critt. Ital. ser. 1, 143, ser. 2, 1067; Ell. N. Amer. Fung. 557c; *Erikss. Fung. par. scand. 137a, 137b, 138, 234a, 234b; *Seym. and Earle, Econ. Fung. 278, 432, and 131a, sub *Sphaerotheca pannosa*; *Wartm. and Schenk, Schweiz. Krypt. 321; *Kneiff. and Hartm., Pl. Crypt. Bad. 158; *Cav. Fung. Long. Exsicc. 30; *Romell, Fung. exsicc. praes. scand. 60.

Amphigenous; mycelium usually evanescent, but sometimes persistent, and forming white orbicular spots or irregular patches on the upper surface of the leaf; perithecia usually somewhat gregarious, but varying from scattered to densely gregarious or even caespitose, 58–120 μ in diameter, cells small, averaging 15 μ wide, but varying from 10–20 μ wide; appendages very variable, few or numerous, usually long, often exceeding 9 times the diameter of the perithecium, more or less straight, septate and colored dark brown throughout, but sometimes short, tortuous, interwoven and pale brown, sometimes even obsolete, very rarely flexuose and more or less shining white throughout; ascus broadly elliptical

to subglobose, rarely shortly stalked, 45–90 × 50–72 μ; spores 8, 20–25 (rarely 30) × 12–18 μ, averaging 22 × 15 μ.

Hosts.—*Agrimonia Eupatoria, Alchemilla arvensis, A. vulgaris, Collomia gracilis, C. heterophylla, C. linearis, Dipsacus laciniatus, D. sylvestris, Epilobium adenocaulon, E. alpinum, E. cephalostigma, E. coloratum, E. hirsutum, E. jucundum, E. montanum, E. palustre, E. parviflorum, E. parviflorum × roseum, E. pubescens, E. roseum, Erodium moschatum, Fragaria glauca, Geranium caespitosum, G. Carolinianum, G. Ibericum, G. incisum, G. maculatum, G. Nepalense, G. palustre, G. pratense, G. Richardsonii, G. sylvaticum, Geum album, G. Kokanicum, G. macrophyllum* (265), *G. strictum, G. Virginianum, Gilia aristella, G. heterophylla, G. linearis, Humulus Japonicus, H. Lupulus, Morina persica, Neillia opulifolia, Phlox longifolia, Potentilla Anserina, P. bifurca, P. Comarum, P. fragarioides, P. glandulosa, P. palustris, P. reptans, P. Tormentilla, Poterium Canadense* and var. *medium, P. officinale* and var. *carneum, P. Sitchense* (cult.), *P. tenuifolium* and var. *album, Pyrus Aria, Rhus copallina, R. glabra, R. typhina* (60) (282), *Ribes floridum, Rosa Arkansana, R. blanda, R. lucida, R. Woodsii, Rubus Canadensis, R. hispidus, R. odoratus, R. spectabilis, R. strigosus* (60), *R. triflorus, Scabiosa Caucasica, Shepherdia argentea, S. Canadensis, Spiraea Aruncus, S. Camtschatica, S. salicifolia* (163), *S. Thunbergii, S. Ulmaria, Viola Canadensis, V. canina* var. *sylvestris.*

Distribution.—Europe: Britain, France, Spain and Portugal (77), Belgium, Netherlands, Switzerland, Italy, Germany, Austria-Hungary, Denmark, Norway, Sweden, Finland, Russia. Africa: Algeria. Asia: Transcaucasia (338), Turkestan, Siberia (Minussinsk), Japan. North America: United States—Maine (163), New Hampshire (124), Massachusetts, New York, Pennsylvania, New Jersey, Virginia, South Carolina, Ohio, Michigan, Indiana, Alabama (12), Tennessee, Illinois, Mississippi, Wisconsin, Missouri, Iowa, Minnesota, South Dakota, Nebraska, Montana, Wyoming, Colorado, Utah, California, Washington, Canada, Newfoundland, New Brunswick, Ontaria.

Var. **fuliginea** (Schlecht)

Alphitomorpha fuliginea Schlecht. Berl. Ges. Nat. Freund. Verh. **1**: 47. 1819.

Erysibe fuliginea Lk. ; Willd. Sp. Pl. **6**: 102 (partim). 1824; Rabenh. Deutschl. Krypt. Fl. **1**: 230 (partim). 1844.

Erysiphe fuliginea Fr. Syst. Myc. **3**: 238 (partim). 1829.

E. communis Fr. Syst. Myc. **3**: 239 (partim). 1829.

E. fusca Fr. Syst. Myc. **3**: 242. 1829.

E. lamprocarpa, var. *plantaginis* Duby, Bot. Gall. **2**: 869 (partim). 1830.

E. doronici Duby, Bot. Gall. **2**: 870. 1830.

Alphitomorpha lamprocarpa, var. *balsaminae* Wallr. Fl. Crypt. Germ. **2**: 758. 1833.

A. communis, var. *personatarum* Wallr. Fl. Crypt. Germ. **2**: 758 (partim). 1833.

A. fumosa Wallr. Fl. Crypt. Germ. **2**: 760 (syn. excl. partim). 1833.

Erysiphe gerardiae Schwein. Syn. Fung. Am. Bor. 269. 1834; Sacc. Syll. Fung. **1**: 22. 1882.

E. erigerontis Canadensis Lév.; Mér. Supp. Rev. Fl. Par. 459. 1843.

Erysibe lamprocarpa, var. *balsaminae* Rabenh. Deutschl. Krypt. Fl. **1**: 232. 1844.

E. communis Rabenh. Deutschl. Krypt. Fl. **1**: 232 (partim). 1844.

E. circumfusa Rabenh. Deutschl. Krypt. Fl. **1**: 232 (partim). 1844.

E. fusca Fr. Rabenh. Deutschl. Krypt. Fl. **1**: 235. 1844.

Erysiphe plantaginis Cast. Cat. Pl. Mars. 188. 1845.

E. xanthii Cast. Cat. Pl. Mars. 188. 1845.

Sphaerotheca Castagnei Lév. Ann. Sci. Nat. III. **15**: 139. *pl. 6. f. 9, 10, 10'* (partim). 1851; Cooke, Micr. Fung. 218. *pl. 11. f. 216* (partim). 1865; Cooke, Handb. Brit. Fung. **2**: 645. *f. 312* (partim). 1871; Syll. Fung. **1**: 4 (partim). 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. 1^2: 27 (partim). 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 94 (partim). 1885; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 400. *f. 3.* 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 64. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 8. *pl. 1.* 1892; Jacz. Bull. l'Herb. Boiss. **4**: 725 (partim). 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 83 (partim). 1897.

Erysiphe detonsa Westend. (non Fr.) Bull. Acad. Roy. Belg. **18** : 403. *pl. 1. f. 3.* 1851.

Sphaerotheca detonsa Kickx. Fl. Crypt. Fland. **1** : 375. 1867. Lamb. Fl. Myc. Belg. **2** : 175. 1880; Sacc. Syll. Fung. **1** : 4. 1882; Oudem. Rev. Pyren. 11. 1884.

Podosphaera Castagnei (Lév.) de Bary, Beitr. Morph. Phys. Pilz. **1** : § xiii. 48. 1870.

Erysiphe fuscata Berk. & Curt. Grevillea, **4** : 159. 1876; Sacc. Syll. Fung. **1** : 19. 1882.

Sphaerotheca drabae Juel, Bot. Notis. 9. 1890; Sacc. Syll. Fung. **9** : 366. 1891; Juel, Bot. Centralbl. **45** : 274. 1891; Juel. Öfvers. K. Vet. Akad. Förh. (Stockholm), 496. 1895.

Meliola (*Meliopsis*) *calendulae* Malb. & Roum. Rev. Myc. **7** : 90. 1886.

Sphaerotheca calendulae (Malb. & Roum.) Malb. Bull. Soc. Myc. France, **4** : xxxii. 1888; Sacc. Syll. Fung. **9** : 366. 1891.

Albigo calendulae (Malbr. & Roum.) Kuntze, Revis. Gen. Plant. 3^2 : 442. 1892.

A. drabae (Juel) Kuntze, Revis. Gen. Plant. 3^2 : 442. 1892.

Sphaerotheca humuli (DC.) Schroet. in Cohn's Krypt. Fl. Schles. **3** : 231 (partim). 1893.

S. Castagnei, var. *submutica* Juel Öfvers. K. Vet. Akad. Förh. (Stockholm), **51** : 497. 1895.

S. erigerontis Oudem. Rév. Champ. Pays.-Bas. **2** : 84. 1897.

Exsicc.: Fckl. Fung. Rhen. 714, 715, 716, 717, 720, 722, 724, 1745, and 651 sub *Erysiphe lamprocarpa;* Rab. Fung. Eur. 1046, 1046b, 1050, 2026, 2414, and 580 sub *Sphaerotheca pannosa* Bon., and 1058, 2034 sub *Erysiphe lamprocarpa;* Westend. Herb. Crypt. Belg. 281, 555, 1056; and 972 sub *E. communis;* Rab. Herb. Myc. ed. 2. *459, 484 sub *Erysibe communis*, and 458 sub *E. lamprocarpa;* de Thuem. Myc. univ. 556, 1839; Syd. Myc. March. 194, 297, 833, 834, 1140, 1239, 1542; and 1639, sub *Erysiphe communis;* and 286 sub *E. lamprocarpa;* and 1147, *3719 sub *E. cichoracearum;* Roumeg. Fung. Gall. exsicc. 1537, 2168, 2657, 2741, 3658, 3739; and 1982, 1985 sub *E. communis;* Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 761 sub *Erysibe personatorum;* and 1304 (A only) sub *E. communis;* ser. 2, 673; Sacc.

Myc. Ven. 145, *630, 631, 632, 633, 629, 899, 1375, 1376, 900, 901; and 611 sub *Erysiphe lamprocarpa;* Kunze, Fung. select. exsicc. 574; Jack. Lein. & Stizenb. Krypt. Bad. 828; de Thuem. Fung. austr. 123, 442, 444, 653, 756; Oudem. Fung. Neerl. exsicc. 272; Speg. Dec. Myc. Ital. 83, 83 bis; Rehm. Ascom. 544, 545, 600, 750; and 450 sub? *E. communis;* Erbar. Critt. Ital. ser. 1, 878, ser 2, 1068; Rab.-Wint. Fung. Eur. 3657; Cooke, Fung. Brit. exsicc. ed. sec. 595 sub *E. lamprocarpa;* Kneiff. & Hortm. Pl. Crypt. Bad. 16; Ell. N. Amer. Fung. 557 a and b; *Seym. & Earle, Econ. Fung. 300a, 300b, 309, 325; Klotzsch Herb. Myc. 1745 sub *Erysibe communis* (in Herb. Mus. Florence); *Ell. & Everh. Fung. Columb. 311, 418, 504; *Krieg. Fung. Saxon. 577, 578, 722, 723; *Wartm. & Wint. Schweiz. Krypt. 725; *Erikss. Fung. par. scand. 290.

Perithecia usually smaller, sometimes only 50 μ in diameter; wall usually harder and more brittle, cells larger, irregularly shaped, averaging 25 μ wide, but varying from 20–30 μ, rarely 40 μ wide; appendages usually short, pale brown, tortuous and interwoven, but sometimes long, nearly straight, and dark brown; spores 20–25 × 12–15 μ.

HOSTS.—*Adenocaulon bicolor, Adenostyles albida, Ajuga ciliata, Arctium majus, Arnica cordifolia, A. montana, Astragalus alpinus, Bartsia Odontites, Bidens cernua, B. chrysanthemoides, B. connata, B. frondosa, B. tripartita, Calamintha Chinensis, Calendula arvensis, C. officinalis, Carpesium abrotanoides, Cnicus Weyrichii,* var. *Grayanum, Collomia linearis* (151), *Coreopsis aristosa, C. aurea* (265), *C. tripteris, Crepis paludosa, C. runcinata, Dimorphotheca fluvialis, Doronicum Austriacum, D. grandiflorum* (294), *Draba alpina,* var. *glacialis, D. hirta, D. incana, Erechtites praealta, Erigeron acris, E. annuus, E. Canadensis, Euphrasia officinalis, Fatoua pilosa,* var. *subcordata, Fragaria glauca* (151), *Gerardia grandiflora, G. quercifolia, Gaillardia aristata, Helianthemum vulgare, Hieracium* sp., *Hydrophyllum Virginicum, Impatiens noli-tangere, I. textori, Inula dysenterica, Lactuca brevirostris, L. Floridana* (97), *L. Raddiana, L. Sibirica, Leontodon autumnalis, Lophanthus anisatus, Melampyrum nemorosum, M. pratense, M. sylvaticum, Microseris aphantocarpha, Pedicularis cheilanthifolia, P. Groenlandica, P. lanceolata, P. pycnantha, P. resupinata, Phlox divaricata* (60), *Physalis Alkekengi, Plantago lanceolata, P. media, Prenanthes alba*

(97), *P. altissima* (60), *P. purpurea*, *Prunella vulgaris*, *Sanvitalia procumbens*, *Saxifraga rotundifolia*, *Scabiosa arvensis*, *Scrophularia canina*, *Senecio Cacatiastrum*, *S. cordatus*, *S. fluviatilis*, *S. Fuchsii*, *S. lugens*, *S. nemorensis*, *S. Sarracenicus*, *S. subalpinus*, *S. triangularis*, *Siegesbeckia orientalis*, *Taraxacum officinale*, *Tellima grandiflora*, *Thalictrum alpinum*, *Troximon glaucum*, *T. officinalis* (151), *Verbena* sp., *Vernonia Noveboracensis* (363), *Veronica longifolia*, *V. spartia*, *V. spicata*, *V. Virginica*, *Viola cucullata* (363), *Xanthium Canadense*, *X. Italicum*, *X. macrocarpum*, *X. spinosum*, *X. strumarium*.

Distribution.—EUROPE: Britain, France, Belgium, Netherlands, Switzerland, Italy, Germany, Austria-Hungary, Roumania, Denmark, Norway, Sweden, Finland, Russia.

ASIA: Turkestan, Siberia (Minussinsk), Japan.

NORTH AMERICA: United States—Maine, Massachusetts, New York, Pennsylvania, Maryland, New Jersey, West Virginia, (249), South Carolina, Ohio, Michigan, Indiana, Illinois, Alabama, Wisconsin, Missouri, Iowa, Minnesota, South Dakota (151), Montana, Wyoming, Colorado, California, Washington; Canada, New Brunswick, Ontario.

Hosts recorded for the aggregate "*S. Castagnei* Lév." *Arabis alpina* (176), *Aster Bellidiastrum* (3), *Caltha palustris* (230), *Carlina vulgaris* (261) (290), *Cichorium Intybus* (214), *Crepis tectorum* (319), *Cucumis sativus* (22) (132) (133) (345) (377), *Cucurbita* (55) (132) (133) (176) (209) (214) (271), *C. maxima* (68), *C. Pepo* (22) (377) (390), *Dipsacus fullonum* (272), *Epilobium angustifolium* (391), *E. tetragonum* (319), *Eupatorium cannabinum* (209) (214), *Geranium dissectum* (176), *G. molle* (205*), *Heuchera parvifolia* (6), *Hieracium sabaudum* (214) *Impatiens Balsimina* (43), *Lapsana communis* (272) (319), *Linaria vulgaris* (107), *Lycium ovatum* (319), *Pedicularis foliosa* (290), *Pentstemon barbatus* (107), *Plantago major* (390 and 391), *Platanus occidentalis* (22) (296), *Potentilla approximata* (235), *P. Pennsylvanica* (347), *Poterium Sanguisorba* (214) (229) (230), *Rhinanthus angustifolius* (319), *R. minor* (3), *Saxifraga punctata* (311), *Scabiosa integrifolia* (214) *Scorzonera* sp. (349), *S. radians* (235), *Senecio Jacobaea* (319), *S. lyratifolius* (3), *S. spathulaefolius* (176), *S. sylvaticus* (22) (344) (345), *S. vulgaris* (230) (263) (353), *Spiraea filipendula* (58),

Thalictrum simplex (348), *Thelesperma filifolium* (288), *Trifolium* (204) (209), *Urtica* (177), *Vitis vinifera* (22).

Burrill (61) was the first to point out that the old "*Sphaerotheca Castagnei* Lév." was an aggregate species, comprising two sets of forms on different host plants which show constant differences in the size of the cells of the outer perithetical wall. Relying on this character, and on others mentioned below, Burrill divided "*S. Castagnei* Lév." into two species. *S. humuli* and *S. Castagnei.* These two plants I have described above under the names of *S. humuli* and its variety *fuliginea*, as from the study of a large amount of material I feel convinced that the two are not specifically distinct.

To separate the two forms as species, Burrill relied on differences in these characters: the size of the cells of the outer perithecial wall, the nature of the appendages, and the size of the spores. *S. humuli* is stated to have cells usually less than 15 μ wide, appendages slender, 3 or more times as long as the diameter of the perithecium, usually colored throughout when mature, mostly free from the mycelium, and spores averaging 20 μ long; *S. Castagnei*, cells 20–30 μ wide, appendages long, stout, usually colored throughout, but sometimes colorless, flexuous, somewhat uneven in width, more or less interwoven with the mycelium, and spores small, about 15 μ long.

The difference in the average size of the cells of the outer wall of the perithecium, here pointed out, is certainly found, but, at the same time, is not quite so sharply defined. In *S. humuli* I have found the cells to vary from 10–20 μ in width, occasionally a single cell may measure 25–28 μ, but the average width may be stated as about 15 μ; in the var. *fuliginea* the cells are much more irregular in shape and measure, from 20–30 μ wide, occasionally reaching to 40 μ (it may be noted that the larger size and the irregularity in shape of each cell is often seen to be caused by the absence of a wall, which is sometimes clearly indicated) across the middle. Occasionally, the cells in the var. *fuliginea* are not wider than 20–25 μ, and very rarely, indeed, as, *e. g.*, in the specimen in Sacc. Myc. Ven. 1376, we find here and there a few cells as narrow as 15 μ—in fact, in this example, the cells have a range of 15–25, or rarely 30 μ in width. On the other hand, in

a few forms of *S. humuli, e. g.*, specimens on *Geum album*, the cells here and there become largely and slightly irregular in shape, and I have found contiguous cells to measure 10 μ and 28 μ wide, although in the specimen in question the cells averaged under 20 μ. Nevertheless, on the whole, with the few and rare exceptions noted above, the difference in the size of the cells is constant and strongly marked, so that there is usually no difficulty in referring at once any specimen, by means of this character, to either *S. humuli* or its var. *fuliginea*. The difference can be well seen by comparing together the two commonest examples of these plants, viz, *S. humuli* on the hop, with *S. humuli*, var. *fuliginea* on the dandelion.

I do not find the other separative characters put forward by Burrill to hold good. Identically formed appendages are found in certain examples of the two plants, and we can only say that as a rule *S. humuli* has longer, straighter, darker colored appendages, while in the var. *fuliginea* they are, as a rule, shorter, paler, and more tortuous. But to this rule there are certainly numerous exceptions, and we find forms of *S. humuli, e. g.*, on *Geum album*, *Rubus*, *Gilia linearis*, *Geranium*, etc., which have appendages identical in all respects with those usually characteristic of the var. *fuliginea*, from which these examples can be separated only by the small size of the cells of the perithecium. Similarly, certain forms of the var. *fuliginea, e. g.*, those on *Microseris tenella*, *Senecio lugens*, etc., have long, deeply colored appendages, very closely approaching those of typical *S. humuli.*

The size of the ripe spores in the two plants is difficult to ascertain, as the spores are formed very tardily, and in many of the most interesting specimens it is frequently the case that no ripe spores are to be found. As far as I have been able to observe, however, the difference in size given by Burrill does not appear to be constant; certainly the spores of the var. *fuliginea* often much exceed the length given by this author, viz, 15 μ; in the specimen in Syd. Myc. March. 297 (on *Veronica longifolia*) they frequently measure 25 μ long.

There remains, therefore, only the difference in the size of the perithecium, and this, while affording a fairly reliable character, cannot, I think, be considered as one of more than varietal importance.

A few words of explanation are necessary in connection with the names here adopted for the two plants. *Erysiphe humuli* DC. (1815), being the oldest name of either of the two, must stand as the specific name of the plant here considered the type and called *S. humuli* (DC.) Burrill. The other plant has, as already mentioned, been called *S. Castagnei* Lév. by Burrill, but this name cannot be retained, and the oldest name *Alphitomorpha fuliginea* Schlecht. (1819) must be adopted in its place. It is true that in Schlechtendal's description the large cells of the perithecium, which form the essential character of the variety, are not mentioned, so that the identity is established solely by means of the host-plant (*Veronica*) given. As, however, we know that on this host it is exclusively the large-celled form which occurs we can safely adopt the name *fulginea*—just as has been already done in fact, in the similar case of "*Erysiphe humuli*" on the hop.

A form of *S. humuli* which occurs on *Pyrus Aria* has been described as a distinct species by de Thuemen under the name of *S. Niesslii*. The separative characters relied upon were the smaller perithecium and ascus, and especially the scattered habit of the plant. In examining a large series of *S. humuli*, however, it is seen that the characters given cannot be considered distinctive of the form on *Pyrus Aria* alone as we find examples on many other hosts, *e. g.*, on *Potentilla*, in which exactly the same habit is found. In specimens on *Potentilla*, just as in "*S. Niesslii*" on *Pyrus Aria*, the appendages of the perithecium tend to become obsolete, perhaps owing to the densely tomentose surface of the host-leaf in both cases. The perithecia of "*S. Niesslii*" that I have examined average 60 μ in diameter (de Thuemen stated the average to be 86 μ). This is rather below the usual size for *S. humuli*, but perithecia of the same size do occur on *Potentilla* and other hosts, with asci o, as small a size as that given for "*S. Niesslii*." It may be noted too, that in *S. humuli* var. *fuliginea* perithecia with a diameter of only 50 μ occur. On the whole, "*S. Niesslii*" cannot be regarded as anything more than a small form of *S. humuli*.

E. epilobii is identical with certain forms of *S. humuli*. No sufficient distinguishing characters have been given in any diagnosis of this form, and it is evident that, as a general rule, specimens have been referred to "*S. epilobii*" merely from their occurrence on species of *Epilobium*.

Erysiphe erodii was the name given by Durieu and Montagne in 1846–9, to a fungus occurring on *Erodium moschatum* at Oran, Algeria. In their account of the plant, the authors described the perithecium as containing many asci. In 1851 Léveillé identified "*E. erodii*" with *Sphaerotheca Castagnei*. The correctness of this identification has since been questioned by Montagne and also by Saccardo ("Asci plures, ergo non *Sphaerotheca*"). An examination of the original Algerian specimens, however, confirms Léveillé's determination, and shows the fungus to agree in all characters with *S. humuli*.

Professor Penzig kindly sent me for examination the type specimen of *S. fugax* Penz. and Sacc. on *Geranium sylvaticum*. The fungus shows these characters: perithecia 80–98 μ in diameter; cells 15–20 μ wide, appendages long, up to 7 times the diameter of the perithecium, colored pale brown for most of their length, ascus 80–95 × 65–75 μ, spores 20–22 × 13–15 μ. I cannot, in fact, find that the plant differs in any way from *S. humuli*, which occurs frequently on species of *Geranium*.

S. drabae Juel is certainly to be referred to *S. humuli* var. *fuliginea*, and the same is the case with the *S. Castagnei*, var. *submutica* of the same author. I am indebted to Professor Juel for specimens (now in the Kew Herbarium) of both these forms. In the original diagnosis, *S. drabae* (on *Draba hirta*) is described as having no appendages, and in a later description, where the plant is recorded as occurring on *Draba incana*, *Astragalus alpinus*, and *Thalictrum alpinum* Juel (186) remarks "Rostrup hat einen Zweifel aber den Wert dieser art ausgesprochen (Bidr. Kundsk. Norges Sopart II. Christiania Vid.-Selsk. Forhandl., 1891) und vermutet dass dieselbe von *Sph. Castagnei* nicht verschieden sei. Bei *Sph. drabae* sind die Perithecien nur am Grunde durch einige Hyphen mit dem Mycel verbunden, aber entbehren gänzlich der Anhängsel." In the numerous specimens of *S. drabae* sent to me, however, I find, as a rule, a few short, pale brown, tortuous appendages on the perithecium, and rarely the appendages are even numerous. In the characters of the appendages, and in the large perithecial cells, the specimens agree perfectly with *S. humuli* var. *fuliginea*. "*S. Castagnei* var. *submutica*" is the ordinary form of the var. *fuliginea* on species of *Melampyrum*.

A species of *Sphaerotheca* was published as *S. pruinosa* by Cooke and Peck, in 1872, with the following diagnosis: "Amphigenous. Mycelium effused, arachnoid, subpersistent. Conceptacles minute, globose, scattered. Appendages few, interwoven, colorless.—On both surfaces of leaves of *Rhus glabra*, Albany, New York. Habit and character of mycelium very distinct from *S. pannosa*. The colorless appendages will not permit of its being confounded with *S. Castagnei*. Sporidia .0007–.0008 in. × .0004 in." Examination of the type specimens on *Rhus glabra*, and of others on *R. copallina*, shows the fungus to possess these characters: mycelium persistent, thin, and effused, perithecia more or less scattered, 70–105 μ in diameter, cells small, 8–15 μ wide; appendages rather few, variable in length, sometimes 6 times the diameter of the perithecium, usually shorter, more or less flexuous or angularly curved, usually more or less refractive and shining white throughout, with the lumen obliterated, sometimes brownish at base, very rarely pale brown nearly to the apex; ascus elliptic-oblong to subglobose, 70–90 μ × 50–65 μ, spores 8, 22–25 × 12–15 μ.

As Cooke remarks, the habit and mycelial characters separate the plant from *S. pannosa*, and the affinity is certainly wholly with *S. humuli*, to which species, indeed, I have felt obliged, for the reasons given below, to unite this form on *Rhus*. When investigating the so-called "*S. pannosa*" of many American mycologists I was at once struck by the resemblance of some specimens of this fungus on Rose-leaves to "*S. pruinosa*." In the first specimen examined, "on cult. roses, Madison, Wis., 1880 (Henry)" (in the Herbarium of the Missouri Botanic Garden), the resemblance was so close that there could be no doubt that the fungus on *Rhus* and this on *Rosa* belonged to the same species. At that time I thought it might be possible, relying on the white shining appendages to keep the plant distinct from *S. humuli*. Since then, however, I have seen more material of this fungus on American roses. For this I am indebted chiefly to Professor Seymour and Professor Clinton, and the specimens sent (now in the Kew Herbarium) show clearly that although this fungus on *Rosa* has in many examples, quite colorless appendages like those of "*S. pruinosa*," in others it may show distinctly colored appendages,

and become indistinguishable from certain forms of *S. humuli.* Evidence on another side also points to "*S. pruinosa*" being only a form of *S. humuli.* The form of *S. humuli* on *Geranium sylvaticum* published by Penzig and Saccardo as "*S. fugax*" is described as having appendages "hyalinae vel basi dilute fuligineae," and it was probably on account of this character that the authors considered their plant as showing affinity with *S. pruinosa.* Although in the type-specimen of "*S. fugax*" the perithecia I examined showed more or less colored appendages, other examples that I have seen of *S. humuli* on species of *Geranium* have had appendages colorless and shining in the upper half quite agreeing in all respects with certain specimens on *Rosa* from America.

It may be objected that as *S. humuli* already contains so many forms which differ in slight characters (*e. g.*, the scattered or clustered habit, a persistent or evanescent mycelium, long or very short or even rudimentary appendages) it is inadvisable to include under the name a form with shining white appendages. But if we were to separate by means of this character, the plant on *Rhus* as even a variety of *S. humuli,* we should have to recognize, it seems to me, very arbitrary and unnatural limits. In the first place, with regard to the specimens on *Rhus,* the occasional occurrence of color in the appendages would have to be overlooked; certain, if not all, specimens on American roses (referred to above) would have to be included in the variety, although forms on species of *Geranium* would be found to completely connect them to the type. It seems more natural, I think, to regard "*S. pruinosa*" as only a form of *S. humuli.* We may perhaps regard this white appendaged plant on *Rhus* together with certain specimens on *Rosa,* as a marked form developing into a new species, but at the present time too closely connected by intermediates to be separated systematically.

Halsted (156) records the occurrence of *S. pruinosa* on *Phytoptus* distortions on the inflorescence of *Rhus glabra.*

S. calendulae (Malb. & Roumeg.), on *Calendula arvensis* is *S. humuli,* var. *fuliginea;* the asci contain eight spores not six as described. Fuckel records a fungus, observed only in the conidial stage on *Rubus Idaeus,* under the name of *Erysiphe? rubi* (Symb.

Myc. 86, Wint. in Rabenh. Krypt. Fl. Deutschl. 1^2: 34. It is probable that this fungus is *S. humuli*, as this species occurs on several American species of *Rubus*. The record of "*S. Castagnei*" on the vine probably rests merely on the occurrence of "*Oidium Tuckeri*" on the plant, as the latter was supposed by Fuckel and others, to be a conidial form of "*S. Castagnei*."

S. humuli, when it occurs on hops, is well-known as "hop mildew," a disease which causes serious injury in hop-gardens. On the leaves, the fungus does not occasion much damage, probably only slightly weakening the vitality of the host-plant, but when it occurs on the cones it materially injures their quality, and in severe attacks causes them to completely shrivel up. The "hop mildew," although recorded on cultivated hops on the Continent in many places, does not apparently cause so much damage there as in England, where it is one of the most dreaded diseases of the hop-grower. In the United States, also, although Burrill (60, p. 6) says that *S. humuli* "is a very destructive parasite, especially on cultivated hops" the disease would appear, judging from the absence of any reports (which have been so much made by American mycologists on other plant-diseases) to be less prevalent or less severe than in English hop-gardens. As in the vine powdery mildew, sulphur has been found to be an efficacious remedy. The best results have followed from the use of flowers of sulphur applied during sunshine. For full details of the preparation and application of the sulphur reference may be made to the papers of Whitehead (392, 393) on the subject.

I cannot confirm the statement made in the Journal of the Board of Agriculture for 1897 (181) that in hop-cones infected by *S. humuli* the mycelial hyphae penetrate into the epidermal cells of the bracts, as in material examined I have found within these cells only the usual haustoria.

Whitehead (393, p. 247) recommends as a preventive method against the hop-mildew the removal of all other plants which are the hosts of the fungus from the hop-gardens, and mentions especially *Taraxacum*, *Senecio vulgaris* and other Composites, and *Plantago*. These host-plants of the old aggregate species "*S. Castagnei*" all belong, however, to the form now separated as *S. humuli*, var. *fuliginea*, while the hop-mildew is caused by the type

S. humuli. The weeds that should be destroyed in English hop-gardens are those which are known to be the hosts of *S. humuli*, viz: *Agrimonia Eupatoria, Alchemilla arvensis, Dipsacus sylvestris*, species of *Epilobium, Geranium*, and *Potentilla*, and *Spiraea Ulmaria.*

We are, however, at present, quite ignorant as to how far any form of a mildew is capable of spreading from one host to another. There is also the question—a most important one for systematists—of the influence of the host-plant upon its parasite. The experimental work necessary to answer these two questions is almost entirely wanting. Magnus (227, p. 68), however, records the following extremely interesting facts: "Ueber die Frage, ob die parasitischen Erysipheen von einer Nährpflanzenart leicht auf eine Art übergehen, sind mir keine Versuche bekannt. Ich selbst habe einen einzigen hierhingehörigen Versuch mit Erfolg aufgestellt. Es war mir auffallend dass *Sphaerotheca Castagnei* Lév. auf zwei so verschiedenen Wirthspflanzen wie *Humulus Lupulus* and *Taraxacum officinale* auftreten sollte, zwei Wirthspflanzen, die ebenso verschieden sind nach ihrer systematischen Verwandlschaft, wie nach der physikalischen Beschaffenheit der Oberfläche ihres Laubes, wie nach ihrer chemischen Beschaffenheit. Ich nahm Anfang Juli 1896 Blätter von *Humulus Lupulus*, die mit dem *Oidium* befallen waren, und legte sie auf die Blätter eines pilzfreien *Taraxacum.* Am 27 Juli zeigten sich auf den Blättern des *Taraxacum* zahlreiche scharf umschriebene Rasen des *Oidium*, and zwar nur auf den Blättern des *Taraxacum*, die ich mit den Mehlthau tragenden Hopfenblättern belegt hatte." Later, Magnus (230), noticing that the two forms on *Humulus* and *Taraxacum* had been considered as distinct species by Burrill, thus commented on his experiment: "Nur möchte ich bemerken, dass ich mit Erfolg das *Oidium* von *Humulus Lupulus* auf *Taraxacum officinale* geimpft habe. Dies braucht nicht zu widersprechen der Auschauung, dass meistens auf Compositen und auf *Humulus Lupulus* verschiedene *Sphaerotheca*-Arten auftren, da recht gut so wohl auf dem Hopfen (auf dem ich selbst *Sphaerotheca humuli* (DC.) und *Phyllactinia suffulta* (Rebent.) Sacc. bemerkt habe und auf dem Burrill (N. Amer. Pyren.) noch *Erysiphe cichoracearum* DC. angiebt), als auch auf *Taraxacum officinale* zwei nahe verwandte Sphaerothecen gedeihen könnten."

Magnus' experiment is valuable in showing that the conidia of *S. humuli* will germinate and produce a conidia-bearing mycelium when shown on a house plant upon which (it is almost safe to say) the ascigerous stage never occurs in nature. Unfortunately, the experiment was not continued long enough to ascertain whether perithecia would be produced. It is possible that the fungus would not have been capable of producing these on the unusual host-plant. This supposition would explain the fact of *S. humuli* never having been recorded on *Taraxacum*, although in nature its conidia may frequently germinate upon this extremely common plant. On the other hand, it is possible that the conidia of *S. humuli* might have ultimately produced upon the *Taraxacum* the large-celled perithecia which we at present consider distinctive of the var. *fuliginea* (which is very common on *Taraxacum*); in other words, it is possible that the difference in size of the cells of the perithecial wall is due to the effect of certain different host-plants on the same species of a parasitic fungus. We know that in some forms of certain species of the Erysiphaceae, characters to which even specific value has been given are directly correlated with the occurrence of the fungus on a certain host-plant—"*Microsphaera pulchra*" on *Cornus alternifolia* affords a good instance. In this plant which is now allowed by all mycologists to be only a form of *M. alni*, a characteristic and more elaborate branching of the apex of the appendages is connected with the occurrence on *Cornus*; in the case of *S. humuli* a similar correlation may exist between the size of the cells, of the perithecium and the host-plant.

S. humuli, in addition to causing the hop-disease, sometimes seriously attacks cultivated strawberries. In America the disease is known as the "strawberry mildew," and is stated (8) to attack the fruit (both ripe and unripe) and fruit-stalks, as well as the leaves of strawberries. The fungicide recommended is a mixture composed of a quarter of an ounce of sulphide of potassium in a gallon of water; or, according to Humphrey (169), a preparation made as follows: one ounce of carbonate of copper, mixed with five ounces of carbonate of ammonia, and dissolved in a quart of hot water; when dissolved, sixteen gallons of water are added.

In the Journal of the Board of Agriculture for 1898 (183) a

disease is described which seriously affected some English strawberries during that year. Its attacks are described as follows: "This disease makes its appearance in May, in the form of white spots upon the leaves. These gradually spread and cover the leaf surfaces and extend to the fruit, covering it with white filaments, which may easily be mistaken for common mould. * * It is most rapid and destructive in its action as the fruit approaches ripeness. As in the case of the allied hop-mildew, which "runs" with great rapidity in the hop-cones as they approach maturity, the full virulence of the strawberry mildew is concentrated upon the ripening fruit, so that the latter is spoiled before it is fit to pick." The fungus causing this disease is here identified as *S. phaerotheca pannosa*, but it is most probable that *S. humuli* was really the species that occurred. The description given of the fungus is rather unsatisfactory (*e. g.*, the perithecia are stated to contain several asci); the figures of the perithecium, however—one of which shows a perithecium in section with a single ascus—represent *S. humuli* fairly well. It is recommended that imperfect strawberry plants should be sprayed either with "a weak Bordeaux mixture, composed of 4 lbs. of sulphate of copper and 3 lbs. of lime to 50 gallons of water, or with a composition of 2 lbs. of sulphide of potassium (liver of sulphur) to 50 gallons of water."

S. humuli illustrates in a striking manner the impossibility of placing any systematic value on the position or the scattered or clustered habit of the perithecia. On *Pyrus Aria*, *Potentilla argentea*, etc., the perithecia are uniformly and distantly scattered over the lower surface of the leaf; on perhaps the majority of the host-plants they are more or less gregarious, often on both sides of the leaf, but frequently only on the upper surface, or commonly they occur on the stem; on *Gilia linearis*, etc., the perithecia are closely crowded into dense patches on different parts of the plant, while on *Neillia opulifolia*, and in a few other cases, they are so densely caespitose that they more or less encrust in places considerable portions of the stem, petiole, etc.

Professor Selby has sent me a plant (now in the Kew Herbarium) on *Shepherdia Canadensis* from Michigan, U. S. A., under the MSS. name of *Sphaerotheca shepherdiae*. The distinctive characters were considered to be the crowded habit of the small peri-

thecia which here and there form black masses on the stem, and the rudimentary appendages. After a careful examination of the specimens sent I am quite unable to separate the fungus from *S. humuli*, and feel convinced that it is only one of the many forms of this species, and that the slight characteristics which it presents (which are not, however, confined to the fungus on *Shepherdia*) may be regarded as probably due in this case, to the position of the fungus among the densely arranged peltate scales of the stem of the host-plant. Griffiths (151) records *S. humuli*, var. *fuliginea* on *Shepherdia argentea* and *S. Canadensis*, and Burrill (60) the same on *S. argentea;* probably in both cases the fungus is the one above referred to *S. humuli.*

Except in America, *S. humuli* has not hitherto been distinguished from the var. *fuliginea*, and the European host-plants, as far as I have been able to see specimens of the fungus on them, are here for the first time separated under the two forms. The fungus recorded on host-plants which I have not seen I have been obliged to leave under the aggregate species, "*S. Castagnei* Lev." Many of these hosts, *e. g.*, species of *Epilobium*, *Potentilla*, etc., might probably be safely considered those of *S. humuli;* others, *e. g.*, species of *Senecio*, *Impatiens*, *Balsamina*, etc., as belonging to the var. *fuliginea.*

Although so many authors have referred the fungus on *Cucurbita* and *Cucumis* to "*S. Castagnei*," it seems very probable that a mistake has been made in the identification, and that the fungus in question is an *Erysiphe.* In the first place, although one finds in herbaria very numerous examples of a fungus in the conidial (*Oidium*) stage on leaves of *Cucurbita* and *Cucumis* referred to *S. Castagnei*, in my experience no specimens in the perithecial stage are to be found in herbaria on these hosts. It is evident, therefore, that for some reason it has been the practice among mycologists to name any *Oidium* on *Cucurbita* and *Cucumis*, *S. Castagnei* Lév. There can be no doubt also that this fungus on cucurbitaceous plants is extremely slow in producing perithecia, and the only example I have seen in this condition was gathered in the late summer at Reigate, England, in 1898. This, as already mentioned, proved to be *Erysiphe cichoracearum.*

The practice of referring a fungus in its *Oidium* stage to a

certain species of the Erysiphaceae has led, I feel convinced, to very numerous mistakes, and has made any compilation of a host-index from published records alone utterly misleading.

Further, not only are wrong host-plants for a certain species thus given, but as a natural consequence our knowledge of the geographical distribution of the species in question becomes erroneous. For instance, Winter (111) records the occurrence of "*Sphaerotheca Castagnei*" "in foliis *Cucurbitacearum*" from the island of St. Thomas, Africa, an occurrence extremely interesting not only geographically, but also climatically, as the island is on the equator. In the present confusion it is impossible to say whether the fungus was really "*S. Castagnei*" in a perithecial stage, or, whether, as is more probable, it was not merely an *Oidium* which had been referred to *S. Castagnei* in accordance with the usual custom.

The fungus recorded as "*S. Castaguei*" on apples proves to be *Podosphaera leucotricha;* the records of the present species on *Trifolium* and *Urtica* probably belong to *Erysiphe polygoni.*

2. S. PANNOSA (Wallr.) Lév.

Alphitomorpha pannosa Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 43. 1819; Wallr. Fl. Crypt. Germ. **2**: 760. 1833.

Eurotium Rosarum Grev. Scot. Crypt. Fl. **3**: *pl. 164. f. 2.* 1823, and **6**: Synops. 7, 1826.

Erysibe pannosa Schlecht. Fl. Berol. **2**: 170. 1824; Lk.; Willd. Sp. Pl. **6**: 104. 1824; Rabenh. Deutschl. Crypt. Fl. **1**: 230. 1844.

Erysiphe pannosa Fr. Syst. Myc. **3**: 236. 1829; Duby, Bot. Gall. **2**: 869. 1830; Berk. in Sm. Engl. Fl. **5**: 325. 1836; Tul. Sel. Fung. Carp. **1**: 208. *pl. 4. f. 1–3.* 1861.

Sphaerotheca pannosa Lév. Ann. Sci. Nat. III. **15**: 138. *pl. 6. f. 8.* 1851; Cooke, Micr. Fung. 218. *pl. 11. f. 217, 218.* 1865; Cooke, Handb. Brit. Fung. **2**: 645. 1871; Sacc. Syll. Fung. **1**: 3. 1882; Wint. Rabenh. Krypt. Fl. Deutschl. 1^2: 26. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 94. 1885; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 398 (*partim*). 1887; Cooke, Handb. Austral. Fung. 313. *pl. 25. f. 239.* 1892; Burr.; Ell. and Everh. N. Amer. Pyren. 6 (*partim*). 1892; Schroet.; Cohn's Krypt. Fl.

Schles. 3 : 230. 1893 ; Jacz. Bull. l'Herb. Boiss. 4 : 726. 1896 ; Oudem. Rév. Champ. Pays-Bas. 2 : 82. 1897.

Podosphaera pannosa de Bary, Beitr. Morph. Phys. Pilz. 1 : § xiii., 48. 1870.

Albigo pannosa (Wallr.) Kuntze, Revis. Gen. Plant. 3^2 : 442. 1892.

EXSICC.: Desmaz. Pl. Cr. Fr. ed. 1 : ser. 1 : 404 ; Baxt. Stirp. Crypt. Oxon. fasc. 2 : 92 ; Lib. Pl. Crypt. Ard. fasc. 1 : 80 : Cooke, Fung. Brit. Exsicc. 90, ed. sec. 589 ; Rab. Fung. Eur. 2214 ; Rehm. Ascom. 796 ; Fckl. Fung. Rhen. 725 ; Berk. Brit. Fung. 96 ; * Rab. Herb. Myc. ed. 2 : 459 ; Wahrlich. Parasit. Pilze. 31 (in Herb. Hort. Imp. Petropol.) ; * Syd. Myc. March. 4514 ; * Erikss. Fung. par. scand. 33 ; * Seym. & Earle, Econ. Fung. 131b.

Mycelium persistent, forming on the stem, calyx, petiole, and rarely on the midrib at the back of the leaf, dense satiny patches, at first shining white, but often becoming gray, dingy buff, or rarely pale brown, composed of densely interwoven special hyphae, which are about 6 μ wide, sparingly branched, somewhat rigid, refractive and thick-walled, with the lumen becoming obliterated ; perithecia more or less (usually completely) immersed in the persistent mycelium, globose to distinctly pyriform, 85–120 μ in diameter, usually about 100 μ, cells obscure, about 10 μ wide ; appendages few, often obsolete, very short, tortuous, pale brown, septate ; ascus broadly oblong to globose, 88–115 μ, averaging 100 × 60–75 μ ; spores 8, 20–27 × 12–15 μ.

Hosts.—Prunus Persica, Rosa alba (95), *R. arvensis, R. canina, R. centifolia, R. cinnamomea* (99), *R. damascena, R. dumetorum* (319), *R. Eglanteria* (290), *R. Gallica, R. glauca* (319), *R. pomifera, R. rubiginosa* (319), *R. tomentosa, R. villosa.*

Distribution. — EUROPE. — Britain, France, Portugal (395), Spain (—), Belgium (14) (209), Netherlands (1), Switzerland (176), Italy, Germany, Austria-Hungary (20) (43) (95), Denmark, Norway, Sweden, Russia.

ASIA —Cyprus, Transcaucasia (338), India (85).

AUSTRALIA.—Queensland (89), Victoria, New South Wales and Queensland (225).

NORTH AMERICA.—United States : Tennessee, Illinois (probably in many other states, but has been generally confused with *S. humuli*).

[W. INDIES.—Jamaica (76).]

[SOUTH AMERICA.—Quito, Ecuador (275).]

The present species is sharply marked off from all the species of the *Erysiphaceae* by its pannose satiny patches of persistent mycelium, in which the perithecia are usually completely immersed. Under the microscope these patches are seen to be composed of special hyphal branches from the ordinary vegetative mycelium, about 6 μ wide, somewhat rigid, more or less straight, sparingly branched, with numerous free, somewhat tapering ends. The hyphae are thick-walled, becoming more or less solid at maturity through the obliteration of the lumen, and are shining white and refractive, so that each hypha has somewhat the appearance of a solid glass rod. Among these densely interwoven hyphae the perithecia are produced. These are interesting in being sometimes distinctly pear-shaped; the appendages are short, or quite rudimentary.

Although *S. pannosa* in its *Oidium*-stage (*O. leucoconium* Desmaz.) often covers the upper surface of rose-leaves, I have not been able to find, in the considerable amount of material examined, any perithecia formed here. It is only rarely, indeed, that perithecia are formed on the leaves at all (the stem usually being chosen), and then it is always in the characteristic pannose patches on the petiole or at the back of the midrib, and not scattered over the surface.

It has frequently been asserted that the mycelium of *S. pannosa* is perennial, and reappears in successive years on the same shoots of infected roses, and it has been supposed by many authors that the mycelium is capable of entering at times into the tissues of the host-plant, although no direct evidence exists, apparently, to support this view (*cf.* Winter (394, p. 26) and Schroeter (319, p. 230) where the author remarks: Dieser Pilz kann auf den befallenen Stöcken überwintern und wird selbst durch Pfropfreiser übertragen"). In the examination of shoots of rose-bushes covered with patches of *S. pannosa* in different stages of development, I have found only the usual haustoria in the epidermal cells, and no signs of an internal mycelium. It was noticeable, too, in the specimens examined that the fresh centers of disease which appeared in the spring did not occur at the places (marked by con-

spicuous scars or the nearly black and decaying remains of the old persistent mycelium) where the fungus grew in the previous year. Eriksson remarks on the subject (119): "Die bei diesem Pilze vorhandenen Perithecien scheinen übrigens nicht für sich allein das Fortleben des Mehlthaues in dem Grade wie er dem Gärtner jetzt bekannt ist, genügend zu erklären, besonders wenn man an die in den Gewächshäusern so verheerende, so weil bekannt nie perithecienführende Form der Krankheit denkt. Ihre dortige Lebenskräftigkeit muss unzweifelhaft auf andere Ueberwinterungsweisen, z. B. auf ein unter günstigen Umständen in die peripherischen Gewebe der Nährpflanze eindringendes und da fortlebendes Mycelium, auf ein saprophytisches, hefepilzähnliches Entwicklungsstadium des Pilzes im Sinne Brefeld's oder dgl. zurückgeführt werden. Mikroskopische Beweise für die eine oder andere Annahme sind jedoch noch nich gebracht worden."

In Europe *S. pannosa* is not uncommon, indeed in its *Oidium*-stage it is very frequent, on wild and cultivated roses, although perithecia are produced less commonly. From Asia (Cyprus) Professor Gennardius has sent me specimens on *Rosa damascena*, which are identical with European examples. Cooke (85) states that in India roses suffer the attacks of *S. pannosa* in the same way as they do in Europe; and in the same author's work on Australian fungi (89) *S. pannosa* is recorded (an unsatisfactory figure is given) "on rose-leaves" from Queensland.

How far these records and those of *S. pannosa* from the West Indies and South America rest on the occurrence of an *Oidium*-stage on rose-leaves, identified as that of *S. pannosa* merely from growing on this host-plant, it is impossible to say. The prevalent practice of naming species of the *Erysiphaceae* in the conidial stage cannot be too strongly condemned, for it is not as a rule from reliance on morphological characters that such naming takes place, but simply from the assumption that the species of fungus which occurs on a certain host-plant in one part of the world will be the same as that growing on the same host in other parts.

The danger of making such assumption is well seen in connection with a mildew common on American roses, which on account of its occurrence on roses has been wrongly referred to the present species. To any one familiar with the appearance of *S. pannosa*

in Europe, with its distinct habit, the remark of Burrill (60, p. 6), that the affinity between *S. pannosa* and *S. humuli* is quite as close as between *S. humuli* and its variety *fuliginea* appears strange, and still more so does Earle's note on the specimen of "*S. pannosa*" in Seymour and Earle's Economic Fungi, no. 131a, that "this form is so like *S. humuli* (DC.) Burrill that it causes doubt in my mind as to whether the two can be kept distinct." On examining American material it became at once clear that what has passed in the United States for *S. pannosa* is for the most part a quite distinct species, viz, *S. humuli*. This form of *S. humuli* on rose-leaves is a very interesting one, and when, as is frequently the case, the appendages are colorless and shining, is identical with "*S. pruinosa*" on *Rhus*. At other times however, the appendages are more or less colored, and there seems little doubt that Earle's opinion that the form is not distinct from *S. humuli* is correct.

It is a most interesting fact that in America *S. humuli* should have attacked roses, while in Europe, where *S. humuli* is equally common, only *S. pannosa* is known on this host. The case, however, is quite analogous with that of another species of the *Erysiphaceae*, viz, *Microsphaera alni* which is very common in the United States on *Syringa vulgaris*, yet in Europe, where both the fungus and the host-plant occur frequently, there is no record of the lilac being attacked by *M. alni*.

I have seen only two specimens of true *S. pannosa* from America —one in Seymour and Earle's Economic Fungi, no. 131b, on *Rosa* sp. from Tennessee; the other sent to me by Professor G. P. Clinton "on *Rosa* sp.; stems; Illinois." Owing to the confusion that has existed between *S. humuli* and *S. pannosa*, mentioned above, it is impossible at present to give the distribution of the latter species in America.

S. pannosa is the "rose-mildew," so well known to rose-growers, and if unchecked is a dangerous disease, quickly spreading from bush to bush in its conidial (*Oidium*) stage. As in the case of the vine-mildew, however, a fungicide which is usually efficacious is found in flowers of sulphur, or potassium sulphide (half an ounce of sulphide of potassium dissolved in a gallon of water). For roses grown under glass, Maynard (243) reports that a sure

and safe remedy is found in the use of evaporated sulphur. The author gives these directions: "In the use of this remedy a small kerosene stove with a thin iron kettle was used, and the sulphur kept boiling two or three hours thrice each week, when the house was kept closed. Care must be taken that only enough heat is used to boil the sulphur, and that it is not set on fire." Guercio and Baroni (101*) recommend as a fungicide the following mixture: carbonate or crystals of commercial soda, kg. 1.5, Norwegian vegetable tar, kg. 0.5; water, liters 100. The soda and tar must be boiled together in about two liters of water, and the rest of the water then added at the ordinary temperature. Spraying with this mixture is stated to have been completely successful in checking the disease in cases where the use of sulphur and sulphate of copper had little effect.

The records of "*S. pannosa*" on gooseberry in America belong to *S. mors-uvae*; those on *Rubus*, and probably also on raspberries, to *S. humuli*. The record of *S. pannosa* on *Spiraea Ulmaria* (391) probably refers to *S. humuli*. Worthington G. Smith (330) states that *S. pannosa* "sometimes grows on *Spiraea* and the hop, but hop-mildew is of course a different fungus." Here again, notwithstanding the concluding remark, *S. humuli* has probably been confounded with the present species.

3. S. MORS-UVAE (Schwein.) Berk. and Curt.

Erysiphe mors-uvae Schwein. Syn. Fung. Am. Bor. 270. 1834.

Sphaerotheca mors-uvae (Schwein.) Berk. and Curt. Grevillea, **4**: 158. 1876; Sacc. Syll. Fung. **1**: 5. 1882; Burr. and Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 399. 1887; Burr.; Ell. and Everh. N. Amer. Pyren., 7. 1892.

Albigo mors-uvae (Schwein.) Kuntze, Revis. Gen. Plant. 3^2: 442. 1892.

EXSICC.: Rab.-Wint. Fung. Eur. 3239; Ell. and Everh. N. Amer. Fung. 1536; Roumeg. Fung. Gall. Exsicc. 3882.

Amphigenous; mycelium persistent, when mature forming dense pannose patches, composed of sparingly branched, more or less flexuous, brown hyphae, which are about 5 μ wide, at first pale brown and plainly septate, becoming dark brown and thick-

walled so that the septa and lumen become obliterated; perithecia gregarious, more or less immersed in the persistent mycelium, sub-globose or sometimes slightly irregular in shape, 76–110 μ in diameter, cells large, at first well-defined, then becoming obscure, variable in size, 10–25 μ wide, usually 15–20 μ; appendages usually few (or even obsolete), pale brown, short, and tortuous, rarely more numerous, and longer, up to 5 times the diameter of the perithecium; ascus elliptic-oblong to sub-globose, 70–92, rarely 92–110 × 50–62 μ; spores 20–25 × 12–15 μ.

Hosts.—On the berries, and occasionally stems and leaves of wild and cultivated species of *Ribes; R. cereum* (6), *R. Cynosbati*, *R. divaricatum*, var. *irriguum*, *R. floridanum*, *R. gracile* (—), *R. Grossularia*, *R. Hudsonianum*, *R. lacustre*, *R. Missouriense*, *R. prostratum*, *R. rotundifolium*, *R. rubrum*.

Distribution.—NORTH AMERICA: United States—Maine (163), New York, Pennsylvania! New Jersey (53), Ohio! Michigan, Illinois! Mississippi (361), Wisconsin (97), Missouri! Iowa! Dakota! Nebraska! Montana! Wyoming! Colorado (157) (170).

Botrytis euphorbiae Cast. Supp. Cat. Pl. Mars. 81. 1851.

Erysiphe (*Sphaerotheca*) *tomentosa* Otth, Mitth. natur. Gesell. Bern. 1865: 168. 1866.

Sphaerotheca tomentosa Otth; Jacz. Bull. l'Herb. Boiss. **4**: 723. 1896; Sacc. Hedwigia, **35**: Repert. XXIII. (1896); Dom. Sacc. Att. Soc. Ven.-Treub. Sci. nat., (17) *pl. 5. f. 1.* 1896; Sacc. Syll. Fung. **14**: 462. 1899.

Erysiphe gigantasca Sorok. & Thuem; de Thuem. Myc. univ. no. 645. 1877; Sacc. Syll. Fung. **1**: 18. 1882.

Sphaerotheca gigantasca (Sorok. & Thuem.) Bäuml. in Rehm, Ascom. fasc. XXI. n. 1049. 1891; Hedwigia, **30**: 261. 1891; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 232. 1893.

Albigo tomentosa (Otth) Kuntze, Revis. Gen. Plant. 3^2: 442. 1892.

EXSICC.: de Thuem. Myc. univ. 645*; Syd. Myc. March. 3462 (sub *S. Castagnei*).

Hosts.—*Euphorbia dulcis*, *E. helioscopia*, *E. palustris* (20*), *E. Peplus*, *E. platyphyllos*, *E. stricta*, *E. virgata* (164*).

Distribution.—EUROPE: France, Switzerland, Germany, Austria-Hungary, Denmark, Russia.

S. mors-uvae is distinct from *S. pannosa* (with which it has

been occasionally confused in America) in the dark-brown color of the persistent mycelium, the usually smaller ascus, etc.

In 1865 Otth (262) described a species of *Sphaerotheca* on the leaves and stems of *Euphorbia dulcis* in Switzerland, under the name of "*Erysiphe* (*Sphaerotheca*) *tomentosa*," with the following description; "Epiphylla caulinaque. Subiculum maculaeformi-effusum, tomentosum, rufum, in ambitu albidum, e floccis longissimis, rufis, eseptatis, contextum. Conceptacula subiculo inspersa, subimmersa vel plus minus emersa. Appendiculae a subiculi floccis minime distinctae. Sporangium unicum, sporis octonis foetum." In 1877 the same plant was published as a new species under the name of *Erysiphe gigantasca* by Sorokin and de Thuemen (in de Thuemen's Myc. Univ., no. 654) on the stems of *Euphorbia platyphyllos* and *E. dulcis* in Russia. In 1881 Bäumler (20*) recognizing that Sorokin and Thuemen's plant was a *Sphaerotheca*, called it *S. gigantasca*. Jaczewski in 1896 revived the forgotten name of Otth's *S. tomentosa*.

An earlier name, however, for this plant on *Euphorbia* is that of *Botrytris euphorbiae*, published by Castagne (67) in 1851 for a fungus on *Euphorbia Peplus*. The identity is pointed out by M. Hariot in a note attached to a specimen of "*Botrytris euphorbiae* Cast" in the herbarium of the Paris museum, in which it is stated that in this author's opinion the fungus is "*Erysiphe gigantasca* Sorok. & Thuem." The specimen is very young, and the mycelium has not yet attained its characteristic brown color, but I was able to find a few perithecia, showing a single ascus, and there can be no doubt that the *Botrytis euphorbiae* of Castagne is the same fungus as Otth's *Sphaerotheca tomentosa*.

Although the specific validity of this European fungus on *Euphorbia* has not hitherto been questioned, it appears to me that it cannot be separated from *S. mors-uvae*. After much comparison I have failed to find sufficient characters to separate this European plant on *Euphorbia* from the American one on *Ribes*. Although as a rule the fungus on *Euphorbia* affects the stems rather than the leaves, there are specimens in Otth's herbarium, noted as "forma epiphylla," in which it forms irregular pannose or felted patches on the leaves, exactly resembling those of *S. mors-uvae* on the fruit of American gooseberries. The dark brown hyphae of the

persistent mycelium in the two forms (on *Euphorbia* and *Ribes*) are morphologically the same; the only difference I have been able to detect is that in the form on *Euphorbia* the hyphae are perhaps slightly more flexuous, and the perithecia are sometimes more irregularly shaped, with a slightly larger (especially longer) ascus; but these differences are not, I believe, constant, and at any rate are not more marked than those often found in the forms of one species on different host plants. On the other hand there is so close a resemblance in the habit and general morphological characters of the two forms that I feel compelled to consider them as belonging to one species. It would be extremely interesting if experimental work could be carried out to test the correctness of this view that the fungus on American gooseberries and on European spurges belongs to the same species. The plant on *Euphorbia* is apparently not common in Europe, but where it does occur it should be seen if the conidia are capable of infecting gooseberries; in America attempts should be made to infect species of *Euphorbia* with the conidia of *S. mors-uvae* on *Ribes*.

I have, in two instances, seen perithecia containing three asci in American specimens of *S. mors-uvae;* the asci were much smaller than usual (about $60 \times 35\ \mu$) and ovate-oblong in shape.

The record by Berkeley (35) of the occurrence of the present species on "grapes" is due to some error, as in the specimen (now in the Kew Herbarium) to which reference is made, the fungus is growing on the leaves and the berry of some species of *Ribes*.

In America *S. mors-uvae* is common on wild and cultivated species of *Ribes*, and is well known as a widely-spread disease under the name of the "gooseberry-mildew." As the specific name denotes, the fungus is especially harmful in attacking and destroying the fruit, covering the berries with its persistent felted dark-brown mycelium. It is not, however, confined to the fruit, but often forms large confluent patches on the stems and leaves.

As a fungicide, Goff (147) recommends potassium sulphide. The mixture used was one-half or one-fourth of an ounce of the sulphide to a gallon of water, and was applied "as soon as the leaves had begun to expand (May 3), and the application was repeated after every hard rain until June 24, nine sprayings having been made in all. The new growth, as well as the crop of fruit,

was very perceptibly greater on the treated plants." In a series of experiments, on a large scale, carried on by Close (72) the same fungicide was found the most effective. The potassium sulphide solution here used was of the strength of one oz. to two gallons of water. Spraying should be begun very early, just as the buds are breaking, and continued at intervals of about ten days. It was found that English varieties and their seedlings were, as a rule, more subject to attack than the American varieties.

The gooseberry disease caused by *S. mors-uvae* is confined to North America; the disease, called in Europe the "gooseberry mildew," is due to the attacks of *Microsphaera grossulariae* and is not so dangerous, as it attacks only the leaves of gooseberry bushes.

4. S. LANESTRIS Harkn.

S. lanestris Harkn. Bull. Calif. Acad. Sci. **1**: 40. 1886; Sacc. Syll. Fung. Addit. ad Vols. I–IV: 1. 1886; and **9**: 364. 1891; Burr.; Ell. and Everh. N. Amer. Pyren. 9. 1892.

Albigo lanestris (Harkn.) O. K. Revis. Gen. Plant. 3^2: 442. 1892.

EXSICC.: Ell. and Everh. N. Amer. Fung. sec. ser. 1537; Rab.-Wint. Fung. Eur. 3240; *Seym. and Earle, Econ. Fung. 188.

Hypophyllous; mycelium persistent, when mature more or less covering the under surface of the leaf, and composed of a compact rather dense mass of much-branched, very tortuous, interwoven, brown hyphae, which are thick-walled, or more or less solid through the obliteration of the lumen; perithecia gregarious, imbedded in the persistent mycelium, subglobose, 80–120 μ in diameter, cells of outer wall obscure, irregularly shaped, 10–20 μ wide, inner wall becoming completely free from the outer, formed of sub-hexagonal colorless cells with refractive walls, about 15 μ wide; appendages very short or obsolete, often entirely absent; ascus large, from elliptic- to broadly-oblong, more or less distinctly stalked, 100–130 × 60–75 μ; spores 8, 24–30 × 18–20 μ.

Hosts.—*Quercus agrifolia*, *Q. alba* (12) (361), *Q. macrocarpa*, *Q. minor* (361), *Q. Prinus*, *Q. rubra* (361).

Distribution.—NORTH AMERICA: United States—Alabama, Illinois! Mississippi (361), Missouri! Iowa (361), California!

"Very conspicuous upon the growing shoots of *Quercus agrifolia*—the *Oidium* as a white mealy stratum from Feb.–May, followed by the ascophore on the leaves below. San Francisco" (Harkness, l. c.).

S. lanestris is a very conspicuous fungus in its dense scattered or confluent patches, of a dull, dark-brown color when mature, on the under side of oak leaves. In general habit it approaches, through its persistent brown mycelium, *S. mors-uvae*, from which it is, however, quite distinct in the more closely interwoven hyphae, which are much more tortuous or even angularly bent, the separating inner wall of the perithecium and the larger, usually slightly stalked ascus.

The inner wall of the perithecium is formed of colorless angular cells, about 15 μ wide, with refractive walls, and, as the perithecium approaches maturity, becomes completely separated from the outer wall. When a nearly ripe perithecium is pressed open, the ascus is forced out enveloped in the still unbroken inner wall. Even with a perfectly ripe perithecium, when the free ascus escapes, the inner wall on gentle pressure usually follows the ascus in the shape of a hollow globular body split towards the apex. In this character *S. lanestris* recalls *S. phytoptophila* (see fig. 124).

Burrill (60) says, "The perithecia * * * when carefully separated appear to be absolutely without appendages." Although this is frequently the case, I have occasionally seen a few very short, pale brown appendages at the base of the perithecium, usually very much shorter than, and never exceeding, its diameter.

Harkness (158) described the *Oidium* form of *S. lanestris* as follows "*O. ventricosum;* segments swelling in the center and becoming barrel-shaped, 34–38 × 20–22 μ, and filled with numerous round or elliptic bodies, 5–6 × 2–4 μ, which are freely discharged from the ends, as the joints separate." It seems probable that what was seen was merely the granular protoplasm escaping from injured conidia.

Tracy and Galloway (363) remark of *S. lanestris*, "the dense mycelium completely covers the young leaves and twigs, causing the former to shrivel and cease growing before they attain one-fourth their usual size."

5. S. PHYTOPTOPHILA Kellerm. & Swingle. [Figs. 124–126]

S. phytoptophila Kellerm. & Swingle, Journ. Myc. **4**: 93. 1888; Kellerm. & Swingle, Ann. Rep. Kansas Exper. Sta. **1**: 310. *pl. 4. f. 7–13.* 1889; Sacc. Syll. Fung. **9**: 365. 1891; Burr.; Ell. Everh. N. Amer. Pyren. 9. 1892.

Albigo phytoptophila (Kellerm. & Swingle) Kuntze, Revis. Gen. Plant. 3^2: 442. 1892.

EXSICC.: Kellerm. & Swingle, Kans. Fung. 23; Ell. & Everh. N. Amer. Fung. sec. ser. 2336; Rab.-Wint.-Pazsch. Fung. Eur. 3954; *Seym. & Earle, Econ. Fung. 148.

Mycelium evanescent, or subpersistent; perithecia more or less gregarious, 60–78 μ in diameter, cells small, about 10 μ wide, often indistinguishable, inner wall colorless or pale yellow (cells 10–15 μ wide, with refractive walls), usually separating entirely from the outer wall; appendages usually short, sometimes obsolete, more or less tortuous, pale or dark brown, sometimes as long as 4 times the diameter of the perithecium, septate, occasionally branched; ascus elliptic-oblong to globose, and 60–75 × 42–50 μ; spores 8.20–25 × 12–15 μ.

Host.—*Celtis occidentalis*, on distortions caused by a species of *Phytoptus* (gall-mite).

Distribution.—NORTH AMERICA: United States—Ohio, Indiana, Illinois (60), Missouri, Iowa, Kansas.

Kellerman and Swingle (197) give the following description of the present species: "Mycelium very sparse; perithecia globular, dark brown or black, obscurely reticulate, 60–80 micr., mostly 65–75 micr. in diam., appendages few, more or less evanescent, dark brown, irregular but usually about 6 micr. in diam., and mostly longer than the diam. of the perithecia, often septate. Asci large, hyaline, broadly oval, containing 8 spores, which are hyaline, oval, regular in size, 15 × 24–18 micr. Conidial stage: mycelium more abundant, conidiophores hyaline, erect, total height (including conidia) 150–220 micr. by 9–13 micr. in diam., conidia oval, hyaline, continuous, granular within, 15 × 21–29, mostly 15 × 27 micr.

"The fungus is found associated with *Phytoptus* (an undescribed species) on Hackberry (*Celtis*). The distortions caused by the insect, or perhaps by both insect and fungus, consist of a multitude of abnormal, more or less abortive branchlets that form a compact knot, ½–1½ inches in diam.; a few of the branchlets are prolonged a few inches and themselves bear smaller

knots of similar structure. The abortive branchlets have excessively numerous buds all infected by the insect, and covered by the fungus. The conidial stage is found associated with the perithecia and sometimes even extending out on the twigs to the under side of the leaves. The perithecia are found in the spring but do not mature their spores till late fall or winter."

The more obscure cells of the outer wall of the perithecium, the tendency of the inner wall to separate completely from the outer, and the smaller average size of the perithecium and ascus seem to be the only characters separating the present plant from *S. humuli*, and are hardly important enough, by themselves, to give specific rank. There is some evidence, however, which points to the possibility of *S. phytoptophila* being distinct as a "biological" species, and it is from these considerations, viz: that it is possible that the present plant is a species closely allied morphologically to *S. humuli*, but yet physiologically so dependent on its special host as to be unable to grow elsewhere, that I have kept the two distinct.

In the specimens I have seen of *S. phytoptophila* the inner wall of the perithecium, composed of colorless, angular (often hexagonal) cells with refractive walls, shows a marked tendency to separate completely from the outer wall. When a ripe perithecium is burst by pressure, causing the expulsion of the ascus, the inner wall, often in the form of a hollow oval body split at one side, is forced out at the same time (see Fig. 124). If the perithecium which is opened is immature, the inner wall is frequently pressed out unburst, completely enclosing the ascus. In *S. humuli* the inner wall very rarely, if ever, presents this appearance, usually closely adhering in fragments to the outer wall, or becoming more or less absorbed. The small size of the ascus and perithecium could probably be matched in certain forms of *S. humuli.*

The following observations of Halsted's (155) made on living examples of *S. phytoptophila* are of great interest: "At this season of the year (January) all traces of the mildew are absent from anything except the infested or abnormal branches, and upon these the perithecia are limited to the bud-scales, with a particular preference shown to the lower portion of the scale. Upon further study, the buds infested were found to be much

larger than those upon healthy branches and contained the perithecia in all their tissues. For example, a bud well up from the base of a twig might not show any signs of perithecia upon the exterior, but when the large loose scales were removed the bases of the inner ones would expose a dark covering consisting of the mildew perithecia. Longitudinal sections through such buds showed that the living tissue of an ordinary bud was absent, and its space was occupied by an entangled mass of fungous fruit. . . . As fungus parasites thrive upon compounds rich in albuminous substances, and as the *Phytoptus* induces a rapid and, therefore, comparatively succulent growth upon a tree that normally has a dense wood, firm bark, and minute, closely protected buds, it may, however, not be so strange that the *Sphaerotheca* will flourish upon the distortions caused by the mite when it fails to gain a foothold upon a healthy twig. . . . It was, moreover, observed that in a cross-section of the stimulated branch there was considerable starch scattered through the bark, while in the healthy and mature twigs, where the buds were normal, smooth-coated, and varnished, there was no starch outside the ring of firm wood. This starch in the bark may be the secret of the success of the *Sphaerotheca* upon the infested branches."

It is this apparently intimate association of *S. phytoptophila* with the galls of the *Celtis* that suggests the idea of the plant being biologically distinct, and experiments bearing on this point, either the sowing of the conidia of *S. phytoptophila* on host-plants of *S. humuli* or, conversely, attempts to infect the galls of the *Celtis* with the conidia of *S. humuli* are very desirable.

Kellerman and Swingle (198) mention that they were unable to find any haustoria in living specimens, but consider that this may have been due to the distorted nature of the epidermal cells.

Other cases of the occurrence of species of the *Erysiphaceae* on galls caused by mites are known. The form of *Microsphaera alni* described as "*M. erincophila*" occurs on "erineum" galls on leaves of *Fagus ferruginea; M. alni* also occurs under the same conditions on leaves of *Cephalanthus occidentalis*. In both these cases, the presence of the galls seems to cause the appendages of the fungus to become colored, but there is no reason for considering the form a distinct species,

nor to suppose that any intimate connection exists between the fungus and the mite. I have once seen *Uncinula circinata* on "erineum" galls on the leaves of *Acer rubrum*, and in this instance the unusual habitat had no observable effect on the fungus. Halstead (156) records the occurrence of "*Sphaerotheca pruinosa*" on *Phytoptus* distortions on the inflorescence of *Rhus glabra*. All these cases, however, differ from that of *S. phytoptophila* in one important respect, viz., that the species of fungi recorded are found commonly on the same host-plant when this is not attacked by mites, while *S. phytoptophila* (or any species of *Sphaerotheca*) has not been recorded from *Celtis* unless this host-plant has been altered by the attacks of the *Phytoptus*.

Anderson and Kelsey (7) mention an association with mites of "*S. Castagnei*" on *Shepherdia argentea*, and of *S. mors-uvae* on *Ribes rotundifolium*, stating that "in both cases the distorted leaf-axils, abnormally developed buds, and thickened brittle upper leaves bore the perithecia of largest size and in greatest numbers." Instances are also given of mites occurring with "*S. Castagnei*" on *Geranium incisum*, with *Erysiphe communis* on *Oxytropis Lamberti*, *Astragalus triphyllus*, and *A. adsurgens*, and with *E. cichoracearum* on *Chrysopsis villosa*, *Helianthus* (several species), *Cnicus undulatus*, *Erigeron macranthus* and *Mertensia Sibirica*. In all these cases, however, we may note that the fungus in question occurs commonly on unattached parts of the host-plant mentioned, and in many cases it is very probable that the presence of the mites is merely a coincidence.

UNCINULA Lév. Ann. Sci. Nat. III. **15**: 151. 1851

Perithecia globose to globose-depressed; asci several, 2–8 spored; appendages simple, or rarely (*U. accris*) once or twice dichotomously forked, uncinate at the apex, usually colorless, rarely dark brown at base or throughout. Etym.: dim. of *uncus*.

Distribution.—Europe, Africa, Asia, Australia, North and South America—18 species and 2 varieties.

The genus is distinguished at once by the uncinate apex of the appendages.

Key to the Species of the Genus Uncinula

1. Appendages colored. 2.
   Appendages colorless. 3.

2. Appendages colored for half their length or more. 5. *necator*.
Appendages colored only at base (up to the first septum). 16. *australiana*.
3. Asci 2–3-spored. 4.
Asci 4–8-spored. 6.
4. Asci more than 30, perithecia very large, 215–320 μ in diameter. 12. *polychaeta*.
Asci 4–20, perithecia 85–165 μ in diameter. 5.
5. Appendages 9–25, perithecia average 95 μ in diameter, asci 3–6. 4. *clandestina*.
Appendages 50–130, perithecia average 130 μ, asci 8–20. 8. *macrospora*.
6. Appendages all simple. 7.
Appendages some or all branched. 20.
7. Appendages delicate, narrow, 3–4 μ wide, asci 4–7-spored. 8.
Appendages stouter, wider, or if narrow with asci 8-spored. 10.
8. Asci about 25, perithecia 150–200 μ in diameter. 13. *confusa*.
Asci 5–8, perithecia 86–122 μ in diameter. 9.
9. Appendages 50–160, ½–¾ diameter of perithecium. 7. *parvula*.
Appendages 24–46, 1¼–2 diameter of perithecium, often geniculate. 11. *geniculata*.
10. Appendages stout, 7–8 μ wide near the base. 11.
Appendages narrower near the base. 12.
11. Appendages very few, 6–12, enlarged upwards. 15. *Delavayi*.
Appendages crowded, 20–36, scarcely or not at all enlarged upwards. 18. *Sengokui*.
12. Appendages abruptly flexuose or angularly bent. 13.
Appendages straight. 14.
13. Appendages about equalling diameter of perithecium, flexuose above, not angularly bent, spores usually 8. 9. *flexuosa*.
Appendages 1–2, usually 1½–2 diameter of perithecium, more or less angularly bent, spores 4–6, rarely 7. 1. *salicis*, var. *Miyabei*.
14. Appendages thick-walled, refractive, or rough at base. 15
Appendages thin-walled throughout. 17.
15. Mycelium persistent, densely compacted, perithecia 156–268 μ in diameter. 2. *aceris*, var. *Tulasnei*.
Mycelium evanescent or subpersistent, perithecia 64–146 μ in diameter. 16.
16. Asci ovate or elliptic-oblong, 24–30 μ wide, spores 16–20 $\times$ 8–10 μ. 3. *prunastri*.
Asci broadly ovate to subglobose, 34–40 μ wide, spores 20–25 $\times$ 10–13 μ. 10. *Clintonii*.
17. Asci 4–6-spored. 1. *salicis*.
Asci 7–8-spored. 18.
18. Perithecia 168–224 μ in diameter, appendages not exceeding diameter of perithecium. 6. *circinata*.
Perithecia 76–138 μ in diameter, appendages 1¼–2½ times diameter of perithecium. 19.
19. Perithecia 120–138 μ in diameter, appendages 35–60, mycelium persistent, more or less densely compacted. 14. *australis*.
Perithecia 76–105 μ in diameter, appendages 10–28, mycelium evanescent. 17. *fraxini*.
20. Mycelium densely compacted, appendages mostly simple. 2. *aceris*, var. *Tulasnei*.
Mycelium not densely compacted, appendages all or nearly all branched. 2. *aceris*.

1. UNCINULA SALICIS (DC.) Winter. [Figs. 62, 63, 85]

Erysiphe salicis DC. Fl. Fr. **2**: 273. 1805; Duby, Bot. Gall. **2**: 871. 1830; Tul. Sel. Fung. Carp. **1**: 198. *pl. 2. f. 1.* 1861.

E. populi DC. Syn. Pl. Fl. Gall. 57. 1806; de Bary, Beitr. Morph. Phys. Pilz. **1**: § xiii., 52. 1870.

E. varium Fr. Obs. Myc. (partim) **1**: 206. 1815, and **2**: 366. 1818.

Alphitomorpha adunca, var. *populi* Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 37. 1819.

A. populi Wallr. Ann. Wett. Ges. **4**: 236. 1819.

A. obtusata Schlecht. Berl. Ges. Nat. Freund. Verh. **1**: 50. 1819.

Erysibe populi DC. Gray Nat. Arr. Brit. Pl. **1**: 589. 1821.

E. adunca var. *populi* Lk.; Willd. Sp. Pl. **6**: 111. 1824.

E. obtusata (*salicis*) Lk.; Willd. Sp. Pl. **6**: 117. *pl. 1.* 1824.

E. adunca Schlecht. Fl. Berol. **2**: 169. 1824.

Erysiphe adunca Lk.; Grev. Scot. Crypt. Fl. **5**: *pl. 296.* 1827; and **6**: (Synops.) 9. 1828; Berk.; Sm. Engl. Fl. **5**: *pl. 2.* 327. 1836.

E. adunca, vars. *populi* et *salicis* Fr. Syst. Myc. **3**: 245. 1829.

E. adunca, var. *populi* Duby, Bot. Gall. **2**: 870. 1830.

E. capreae (DC. Herb.) ex Duby, Bot. Gall. **2**: 871. 1830.

Alphitomorpha adunca, var. *amentaccarum* Wallr. Fl. Crypt. Germ. **2**: 755. 1833.

Erysibe adunca var. *amentaccarum* Rabenh. Deutschl. Krypt. Fl. **1**: 235. 1844.

Uncinula adunca Lév. Ann. Sci. Nat. III. **15**: 151. *pl. 7. f. 15.** 1851; Cooke, Micr. Fung. **219**: *pl. 11. f. 221–224.* 1865; Cooke, Handb. Brit. Fung. **2**: 646. *f. 314.* 1871; Peck, Trans. Alb. Inst. **7**: 214. *f. 1–3.* 1872; Karst. Myc. Fenn., **2**: 196. 1873; Sacc. Syll. Fung. **1**: 7. 1882.

U. luculenta E. C. Howe, Journ. of Bot., II. **1**: 170. 1872.

U. heliciformis E. C. Howe, Bull. Torr. Club, **5**: 4. 1874; Sacc. Syll. Fung. **9**: 367. 1891.

U. salicis (DC.) Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 40.

* Excl. syn. *Alphitomorpha depressa*, var. *artemisiae* Wallr. and *Erysibe depressa*, var. *artemisiae* Lk.

1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 94. 1885; Burr. and Earle, Bull. Ill. St. Lab. Nat. Hist. **2**: 410. 1887; Burr.; Ell. and Everh. N. Amer. Pyren. 19. *pl. 2.* 1892; Schroet.; Cohn's Crypt. Fl. Schles. **3**: 245. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 742 (syn. excl. partim). 1896; Oudem. Rév. Champ. Pays-Bas. 87. 1897.

Erysiphe populi Patouill. Journ. de Bot. **2**: 217 (cum icon.). 1888; Sacc. Syll. Fung. **9**: 370. 1891.

Uncinula Columbiana Selby, Bull. Ohio Agric. Exper. Sta. (Techn. Ser.) **1**: 221. *pl. 3. f. 5.* 1893; Sacc. Syll. Fung. **11**: 252. 1895.

U. salicis, var. *epilobii* Vestergr. Botan. Notiser, 256. 1897; Sacc. Syll. Fung. **14**: 462. 1899.

EXSICC.: Bri. e Cav. Fung. par. 69, 171; Fckl. Fung. Rhen. 699, *700, 2236; Cooke, Fung. Brit. Exsicc. *447, ed. 2, 597; de Thüm. Fung. Austr. 130, 131, 132, 236, 655; de Thüm. Myc. univ. 959; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 268, 2195, *ed. 2, ser. 1, 113, 1845; Rehm, Ascom. 549, 550; Rab. Fung. Eur. 560, 1045, 2316, 2317; Rab. Herb. Myc. ed. 2, 464, 465; Rab.-Wint. Fung. Eur. 3046; Baxt. Stirp. Crypt. Oxon. fasc. 2, 29; Karst. Fung. Fenn. 367; Sacc. Myc. Ven. 615, 890; Ellis, N. Amer. Fung. 425; Roumeg. Fung. gall. exsicc. 970; Syd. Myc. March. 836, 1657, 2329; Jack, Lein. and Stizenb. Krypt. Bad. 630; Westend. Herb. Crypt. Belg. 80; Ellis and Everh. Fung. Columb. 109, *314; Ellis and Everh. N. Amer. Fung. 3007; *Wartm. and Schenk, Schweiz. Krypt. 320; *Kneiff. and Hartm. Pl. Crypt. Bad. 17; *Seym. and Earle, Econ. Fung. 198; *Hoppe, Fung. Epiphyt. 5, 6, sub *Sclerotium erysiphe* Pers.; Jacz. Kom. Tranz. Fung. Ross. Exsicc. 28 (in Herb. Hort. Imp. Petrop.); *Erikss. Fung. par. scand. 34; Schleich, Crypt. exsicc. 77 (in Herb. DC.).

Amphigenous; mycelium evanescent, or persistent and then usually thin and effused, but sometimes densely compacted and forming definite circumscribed patches; perithecia densely gregarious or more or less scattered, globose-depressed or lenticular, 90–175 μ in diameter, averaging 135 μ, cells 10–15 μ wide; appendages usually numerous, often densely crowded and 100–150, or more, sometimes fewer, rarely only 30–15, ¾–2½ times the diameter of the perithecium, simple, aseptate, or occasionally 1-

septate at the base, hyaline and thin-walled throughout, usually gradually and slightly enlarged upwards, apex simply uncinate or occasionally more or less helicoid; asci 8–14, rarely only 4–6, elliptic-oblong or broadly ovate, usually stalked, 55–80 × 30–40 μ, averaging 68 × 36 μ; spores 4–6, 20–26 × 10–15 μ.

Hosts.—*Populus alba*, *P. angustifolia* (6), *P. balsamifera* and var. *candicans*, *P. ciliata*, *P. grandidentata*, *P. heterophylla*, *P. monilifera*, *P. nigra*, *P. pyramidalis*, *P. tremula*, *P. tremuloides*, *P. trichocarpa*, *Salix alba*, *S. angustifolia* (57), *S. aurita*, *S. Capraea* and var. *pendula*, *S. cinerea*, *S. cordata*, *S. daphnoides*, *S. discolor*, *S. flavescens* and var. *Scouleriana*, *S. fragilis* (22) (344), *S. glauca* (6), *S. humilis*, *S. incana* (230), *S. livida*, *S. longifolia* (6), *S. nigra* and var. *falcata*, *S. nigricans*, *S. petiolaris*, *S. purpurea*, *S. pyrolaefolia* (347), *S. repens*, *S. sericea*, *S. Seringiana*, *S. triandra*, *S. Urbaniana*, *S. viminalis* [*Betula alba* (107) (176) (204) (214) (307) (394), *Buxus sempervirens* (383)].

Distribution.—EUROPE: Britain, France, Portugal, Belgium, Netherlands (263), Germany, Switzerland, Italy, Austria-Hungary, Denmark, Norway, Sweden, Finland, Russia.

ASIA: Transcaucasia (338), Siberia (Minussinsk), India, China (Yunnan), Japan.

NORTH AMERICA: United States—Maine, Vermont, Massachusetts, New York, New Jersey (53), Carolina (90), Ohio, Michigan, Indiana, Illinois, Mississippi (361), Wisconsin, Missouri, Iowa, Minnesota, Kansas, Dakota, Montana, Wyoming, Washington, California. Canada—Ontario, Quebec.

The most widely distributed and the most variable species of the genus, but, as a rule, easily recognized by the numerous simple appendages slightly exceeding the diameter of the perithecium. The appendages are usually slightly enlarged upwards (but not sufficiently so as to make the apex club-shaped) and remain hyaline and thin-walled throughout, not becoming thick-walled or refractive towards the base, as is the case with several allied species.

Although there can be no doubt that the two forms growing respectively on poplars and willows constitute but a single species, we usually find these two forms characterized as follows. The form of *U. salicis* occurring on species of *Salix* has uniformly larger peri-

thecia, the appendages in proportion to the diameter of the perithecium are shorter, nearly always more or less crowded, and have a small and closely uncinate apex; the asci are usually 4-spored. In the form of *U. salicis* occurring on species of *Populus* the perithecia average smaller, the appendages are fewer—in rare cases as few as 15—longer, more flaccid, with the apex frequently more loosely uncinate, and the asci are more often 6-spored. So many examples, however, on both *Salix* and *Populus* show characters intermediate in every respect—for instance, it is not at all uncommon to find forms on *Populus* in which the appendages are very crowded —that, as already mentioned, the two forms cannot be considered specifically distinct. We may, however, perhaps regard them as incipient species which are being evolved on different host-plants.

Léveillé (214), Winter (394), Jaczewski (176), Saccardo (307), and other authors have recorded *U. salicis* as growing on *Betula*, but I have not been able to find specimens on this host-plant in any herbarium. It may be that perithecia (without appendages) of *Phyllactinia corylea*—a species which occurs commonly on *Betula*—have been mistaken for immature examples of the present species, and the same suggestion may be made with regard to Wallroth's (383) record on *U. salicis* on *Buxus sempervirens*.

Léveillé (214, p. 151) recorded *Artemisia vulgaris* as a host-plant for *U. salicis*, and (l.c., p. 152) gave "*Alphitomorpha depressa* var. *β artemisiae* Wallr." as a synonym of the present species. Léveillé remarked, "J'ai reçu beaucoup d'échantillons d'Erysiphés sur l'Armoise sous le nom d' *Erysiphe depressa*, et pas un ne se rapporte avec celui de Wallroth, que renferme l'herbier de M. DeCandolle. C'est cette espèce que je réunis à l'*Uncinula adunca* [*U. salicis*], parce qu'elle en présente tous les caractères; l'autre est un Erysiphé proprement dit." In Berkeley's herbarium, at Kew, there is a specimen from Léveillé's herbarium, labelled in the latter author's handwriting "*Uncinula adunca. Alphitomorpha depressa* Wallr. *β. artemisiae.* Specim. Wallrothii."

On this specimen (on the leaf of *Artemisia vulgaris*) there are two species, viz: *Uncinula salicis* and *Erysiphe cichoriacearum*. Of the former species, I found only two perithecia. These were quite loose and merely entangled in the hairs of the leaf, and I feel no hesitation in regarding their presence as accidental. Wallroth's

Alphitomorpha depressa, var. *artemisiae* is certainly *Erysiphe cichoraeearum*, as an examination of Wallroth's type shows. Other authors also (107) (204) have stated that *Uncinula salicis* occurs on *Artemisia*, but it is very probable that the statement is often copied from Léveillé. Pâque (270) has lately (1885) recorded *U. salicis* on this host, but the specimens kindly sent to me by this author prove to be *Erysiphe cichoriacearum*.

The record by Cooke and Peck (91, p. 170) of the occurrence of the present species on *Aesculus* is a mistake, and refers to *Uncinula flexuosa*.

Uncinula luculenta E. C. Howe is one of the forms of *U. salicis* on poplar, and has been correctly referred to this species by American botanists.

U. heliciformis E. C. Howe (on *Populus balsamifera* in the United States) cannot be separated from *U. salicis*; although it is in certain respects a marked form. Howe (167) described the appendages as "spirally coiled above, colored at base," and on a specimen (now in the Kew Herbarium) sent to Cooke, has remarked, "possibly a variety which unites *U. spiralis* B. & C. with *U. ampelopsidis* Peck." An examination of this specimen showed the perithecia to be 80–120 μ in diameter with 24–38 colorless aseptate appendages, about 1 ½ times the diameter of the perithecium. The apex of the appendages is, when mature, 2–3 times coiled in a helicoid manner (Fig. 85), and in this respect is similar to that of *U. necator* (*U. spiralis*). In all other characters, however, especially in the colorless aseptate appendages "*U. heliciformis*" shows no affinity whatever with this species. It is certain, too, that a more or less helicoid apex to the appendages must be regarded as a character of very little value, as it appears occasionally in species which normally have a simply uncinate apex, *e. g.*, *U. macrospora*, *U. fraxini*, etc. Among some specimens of *U. salicis* sent to me by Professor Massalongo, from Italy, an example occurs on *Populus nigra* in which many, though not all, of the appendages have a distinctly helicoid apex. On the whole, therefore, "*U. heliciformis*" must be ranked as only an interesting form of *U. salicis*.

Erysiphe populi Patouill. on *Populus tremula* from China (Yunnan) is *U. salicis*, and was described from immature peri-

thecia before the appendages had become uncinate (see figure in Journ. de Bot. 2: 217. 1888). M. Patouillard kindly sent me specimens (now in the Kew Herbarium), on which was noted "*Erysiphe* (*Uncinula*) *populi* Pat.; diffère de *U. adunca* [*U. salicis*] par ses thèques sub-6-spores." Examination showed the asci to be 4–6-spored, and in this and all other characters M. Patouillard's plant agrees perfectly with *U. salicis*.

U. Columbiana Selby was published as growing on *Scutellaria lateriflora* at Columbus, Ohio. The author remarked (324), "This species resembles *U. circinata* C. & P. in the form of perithecia, but is distinguished from it by the more abundant mycelium, by the broader asci, and the fewer and larger spores. Unlike previously reported species of the genus its host is a herb and one commonly affected by an *Erysiphe*. The material on hand is mature though rather scanty." Professor Selby very kindly sent me the type specimens for examination. I found the perithecia to measure 100–150 μ in diameter, the appendages are numerous, hyaline and thin-walled throughout, simply uncinate, 1–1½ times the diameter of the perithecium; the asci are about 60 × 35 μ, 5- or 6-spored, spores 20–22 × 10 μ. In all respects, therefore, the specimen agrees well with *U. salicis*; *U. circinata* differs in the larger perithecia, shorter appendages, larger asci, and 7–8 spores. Professor Selby's material shows some perfectly ripe perithecia, but is rather scanty, and I have not been able to satisfy myself perfectly that the *Uncinula* was *growing* on the *Scutellaria*. There is certainly a species of mildew growing on the *Scutellaria* leaves, as is shown by the presence of some young perithecia on the mycelium, but, as far as I have been able to see, these are too young to show any appendages, and it is just possible that they do not belong to the *Uncinula*, but to *Erysiphe cichoracearum*, which is not uncommon in America on this *Scutellaria*. The *Uncinula* has not been reported subsequently on *Scutellaria*, and considering that there is a possibility that its presence on this plant was accidental, it will be wiser to wait for confirmation before recording *Scutellaria lateriflora* as a host plant for *Uncinula salicis*. Perhaps a parallel case to the above is afforded by the occurrence of *U. geniculata* on *Hydrophyllum*, mentioned below or of *U. salicis* on *Artemisia* (see above). By a curious mistake Saccardo gives, in

his Host Index, "*Uncinia Columbiana*" as the host plant of Selby's species.

U. salicis has been hitherto recorded from Asia only from Siberia (Minussinsk). It appears, however, to be not uncommon in Japan, whence Professor Miyabe has sent me specimens on five species of *Salix* and on three species of *Populus;* from China (Yunnan) it has been recorded, as mentioned above, under the name of *Erysiphe populi.* The present species occurs also in India, but has been recorded as *Erysiphe Martii* by Cooke, in Grevillea (83). The specimen, collected at Simla on *Populus ciliata*, is in the Kew Herbarium; it is somewhat immature, but shows some fully ripe and characteristic perithecia.

Oestergren (372) has recently described a fungus from Upsala, under the name of *Uncinula salicis* (DC.) Wint. var. *epilobii* n. v., on which the following interesting observations (here given in translation) are made:

"The host-plants which are given in the literature for *Uncinula salicis* belong to the genera *Salix*, *Populus* and *Betula;* it was, therefore, quite surprising to find the above form, which very closely agrees with *U. salicis*, on a host so widely different from these genera as *Epilobium angustifolium. U. salicis* appears, however, to have been once before recorded on a herbaceous plant, as Winter (Die Pilze Deutschl. etc., **2**: 40) remarks that this species "soll auch auf *Artemisia vulgaris* gefunden worden sein, doch erscheint diese Angabe sehr unwahrscheinlich." As mentioned above, the form found on *Epilobium* agrees in its chief characters with *U. salicis.* It appears worthy of note that the appendages which are here so numerous at the base of the perithecium are only of the same length as the perithecium, while in the type on the contrary they attain to quite double this length, and it is worthy of remark, also, that at the time of maturity of the fungus the mycelium appears to have almost completely disappeared, while in the type, on the other hand, it is generally persistent. I have, however, found the same behavior with regard to the mycelium in several examples of *U. salicis* in the botanical collections of the Upsala Museum. As the biological adaptation of the *Erysipheae* to different host-plants is almost unknown, it may be best to denote the morphological agreement of this form with *U. salicis*

by placing it as a variety under this species, although it is, perhaps, not improbable that it is, biologically, distinct from it. The most obvious presumption would be that the perithecia of the *Uncinula* in question had been transferred by the wind to the *Epilobium* from, *e. g.*, some *Salix* bushes growing in the neighborhood. Apart from the fact that there were none of the usual host-plants of *U. salicis* in the neighborhood one must quite reject this presumption when one observes (under a slight microscopic magnification) how firmly the perithecia of the var. *epilobii* are fixed to the substratum by means of the appendages radiating on all sides. Moreover, the infected shoots were densely covered along their entire length with perithecia, whereas no signs of the fungus could be found on herbaceous plants growing in the neighborhood."

I have not seen a specimen of this *Uncinula* on *Epilobium*, but from the diagnosis and the author's remarks there seems no reason whatever for separating it from *U. salicis*. Certainly the characters chiefly relied upon, viz, the length of the appendages and the evanescence of the mycelium, cannot be considered distinctive of the "var. *epilobii*" (cf. the diagnosis of *U. salicis* given at p. 82). The question whether any form on a certain host-plant is biologically distinct can only be answered by experiment, for its mere assumption would lead to the establishment of a new "biological" variety or species at each occurrence of a species on a new host-plant. Also, remembering the case of the accidental occurrence of *U. salicis* on *Artemisia* (and perhaps also on *Scutellaria*) mentioned above, it will be best to wait until perithecia have been seen growing on a mycelium on the *Epilobium* before recording the latter as a host-plant for *U. salicis*, although in the present case the crowded habit of the perithecia makes it seem probable that the *Epilobium* was serving as a host-plant.

The fungus described as parasitic on perithecia of *Uncinula salicis* by Cocconi (75*), under the name of *Phoma uncinulae*, is probably *Ampelomyces*.

Var. **Miyabei** var. nov. [Figs. 73–78]

Amphigenous, or epiphyllous; mycelium usually evanescent, or (on the upper surface of the leaf) subpersistent, thin and effused, rarely forming definite spots; perithecia gregarious or more or

less scattered, globose-depressed, 70–120 μ in diam., aver. 95 μ, cells about 10 μ wide; appendages 11–48 in number, usually from 20–30, 1½ to twice the diameter of the perithecium, very rarely only equalling the diameter, simple, smooth or often rough towards the base, aseptate, thin-walled and hyaline above, often becoming refractive at the base, 4–6 μ wide, usually slightly enlarged upwards and about 6 μ wide, more or less abruptly flexuose or angularly bent in the upper half, sometimes irregularly swollen or sub-nodulose, apex simply uncinate, or frequently sub-helicoid; asci 4–7, broadly ovate to subglobose, with or without a short stalk, 40–56 × 30–38 μ; spores 4–6, or rarely 7, 19–21 × 10–12 μ.

Hosts.—*Alnus incana*, *A. maritima* (*A. Japonica*).

Distribution.—ASIA: Japan (Sapporo, K. Miyabe, October, 1890, September, 1894, September and October, 1895, on *Alnus Japonica;* G. Yamada, September, 1896, on *A. incana*).

The present plant shows some affinity with *U. geniculata* and *U. flexuosa* in the usually flexuose or angularly bent appendages, but in all other characters it is so closely allied to *U. salicis* that it seems best to place it a variety under this species. In the notes which Professor Miyabe sent with the specimens of Japanese *Erysiphaceae*, the present plant is thus referred to: "Related to *U. salicis*, but perithecia smaller (100 μ). Appendages fewer in number (22–30), slightly flexuose and nodose, longer (180–200 μ)." In certain forms of *U. salicis* on poplar, however, we meet with perithecia only 90 μ in diameter, with only from 15–30 appendages, which frequently reach to 2½ times the diameter of the perithecium. As a rule, however, *U. salicis* can be at once distinguished from the present variety by the larger size of the perithecia, which average 135 μ in diameter (those of the variety averaging 95 μ), and the more numerous appendages.

It is, however, by certain characters of the appendages that the var. *Miyabei* is best distinguished. If several perithecia are placed under the microscope, it will be seen that the appendages of by far the greater number are abruptly flexuose or angularly bent in the upper half, as shown in figs. 73, 74, 75, and in this respect are somewhat similar to those of *U. geniculata*. Further, the appendages of the var. *Miyabei* become, when mature, refractive and thick-walled at the base, whilst in the type, as far as I have seen, they invariably remain thin-walled throughout.

At first sight, the present variety appears to much resemble *U. geniculata*, but on closer comparison it is seen that in the latter species the appendages are always distinctly narrower, not enlarged upwards and more delicate.

Rarely, the appendages of the present plant are more or less regularly flexuose and not angularly bent; there is then some slight approach towards *U. flexuosa*, which differs in the shorter appendages, 8-spored asci, etc. Very rarely, and perhaps abnormally, a single appendage is found branched at the apex (figs. 76, 77).

The only example sent on *Alnus incana* differs from those on *A. Japonica* in the mycelium forming definite spots on the upper surface of the leaf. The perithecia are seated on these, and as a rule, although not invariably, are larger.

2. U. ACERIS (DC.) Sacc. [Fig. 87]

Mucor Erysiphe Linn. Sp. Pl. **2**: 1186 (partim). 1753.

Erysiphe aceris DC., Syn. Pl. Fl. Gall. 57. 1806; Duby, Bot. Gall. **2**: 870. 1830; Tul. Sel. Fung. Carp. **1**: 197. *pl. 2. f. 2, 3.* 1861; de Bary, Beitr. Morph. Phys. Pilz. **1**: § xiii., 52. 1870.

E. varium Fr. Obs. Myc. (partim) **1**: 206. 1815; **2**: 366. 1818.

Alphitomorpha bicornis Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 38. 1819; Wallr. Ann. Wett. Ges. **4**: 235. 1819; Wallr. Fl. Crypt. Ger. **2**: 755. 1833.

Erysibe aceris DC., Gray, Nat. Arr. Brit. Pl. **1**: 589. 1821.

E. bicornis (*acerum*) Lk.; Willd. Sp. Pl. **6**: 112. 1824; Rabenh. Krypt. Fl. Deutschl. **1**: 235. 1844.

Erysiphe bicornis Fr. Syst. Myc. **3**: 244 (partim). 1829; Berk.; Sm. Engl. Fl. **5**: 327. 1836; Corda, Icon. Fung. **2**: 28. *pl. 13. f. 100.* 1838.

Uncinula bicornis Lév. Ann. Sci. Nat. III. **15**: 153. *pl. 7. f. 17* (partim). 1851; Cooke, Micr. Fung. 219. *pl. 11. f. 225–228.* 1865; Cooke, Handb. Brit. Fung. **2**: 647. 1871.

U. aceris (DC.) Sacc. Syll. Fung. **1**: 8. 1882; Wint. in Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 41. 1884; Schroet. in Cohn's Crypt. Fl. Schles. **3**: 246. 1893; Jacz. Bull. l'Herb. Boiss. **4**:

738 (excl. syn. *U. Tulasnei* Fckl.). 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 88. 1897.

EXSICC.: Rab.-Wint. Fung. Eur. 2941; Brit. and Cav. Fung. par. 70; Rehm. Ascom. 77; Sacc. Myc. Ven. 146; de Thüm. Fung. austr. 133, and Myc. Univ. 154; and (cum *Phyllactinia corylea*) 1055; Syd. Myc. March. 143, *658, *3674, *4231; Kunze. Fung. select. exsicc. 236, 575; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 267, 1112; *ed. 2, ser. 1, 512; Vize. Fung. Brit. 197; and *198 sub *Microsphaera Hedwigii;* Westend. Herb. Crypt. Belg. 550; Cooke, Fung. Brit. Exsicc. 93, ed. 2, 282; Jack, Lein. and Stizenb. Krypt. Bad. 51; Ayres, Myc. Brit. 78; Roumeg. Fung. Gall. Exsicc. 971; Fckl. Fung. Rhen. 701; Klotzsch, Herb. Myc. 179; *Rab. Fung. Eur. 559; *Wartm. and Schenk. Schweiz. Krypt. 212; *Kneiff. and Hartm. Pl. Crypt. Bad. 14; Erb. Critt. Ital. ser. 2, 818, 1364 (in Herb. Mus. Florence).

Amphigenous; mycelium evanescent, or persistent as a thin effused film; perithecia scattered or subgregarious, hemispherical or globose-depressed, large, 120–225 μ in diameter, usually about 180 μ, cells ill-defined, about 10 μ wide; appendages numerous, ½–¾, rarely equalling the diameter of the perithecium, smooth, colorless, thick-walled to the apex, usually a very few simple, the rest bifid, with occasionally one or both of the branches again forked, apex of the simple appendages or of the branches uncinate; asci 4–12, usually 6–10, sub-pyriform or oblong, with or without a short stalk, 70–95 × 45–55 μ; spores usually 8, rarely 6, 22–26 × 13–15 μ.

Hosts.—*Acer campestre, A. monspessulanum, A. pictum, A. platanoides, A. pseudo-platanus, A. rubrum* (394), *A. spicatum, A. tataricum* [*Phillyrea media* (214)].

Distribution.—EUROPE: Britain, France, Belgium, Netherlands (263), Germany, Switzerland, Italy, Austria-Hungary, Denmark, Sweden, Russia.

ASIA: Transcaucasia (338), Japan.

U. aceris is recognized at once by its forked appendages (Fig. 87) which more or less cover the upper half of the perithecium, forming a kind of crown (see Tulasne's beautiful figures, Sel. Fung. Carp. **1**: *pl. 2. f. 2–3*).

Nearly all authors have described the perithecia as becoming

depressed, or pezizoid in age. This statement rests on a curious misconception. On looking at a leaf on which there are mature examples of *U. aceris* we nearly always find that some perithecia, as seen from above, appear very concave, or even cup shaped; a closer examination, however, shows that these are perithecia which have become turned over, so that the upper half, with the appendages which it bears, is pressed to the surface of the leaf. The base of the perithecium, thus exposed, soon loses all traces of mycelial hyphae, and becomes concave, simulating the truly "pezizoid" perithecia of such species as *Erysiphe taurica*. Whether this turning over of the perithecium is natural, and due to some growth of the mycelium or action of the appendages, or whether it is accidental, I am not able to say. The appendages, which through the turning over of the perithecium are pressed against the leaf, sometimes seem to become slightly attached to it, and it is noticeable that the apices of these appendages show, under the microscope, signs of having become slightly disorganized; they may possibly, therefore, adhere to the leaf through some mucilaginous degeneration. Observations on living plants are necessary before the question of how this curious reversal (already in 1861 observed by Tulasne (370)) of the perithecia takes place can be answered.

Acer campestre and *A. pseudo-platanus* are the usual host-plants of the present species; it is only very rarely indeed that *U. aceris* occurs on *A. platanoides*, being usually replaced on this host by the var. *Tulasnei*,* and it is not common on the other species of *Acer* mentioned (*A. monspessulanum*, *A. rubrum*, etc.). The Japanese examples occurred on *A. pictum* and *A. spicatum*, and are very interesting geographically.

As a rule, the simple appendages are very few in number, and more or less completely hidden by the very numerous forked ones; on *Acer tartaricum*, however, the simple appendages are numerous, and this form certainly shows an approach, in this respect, to the var. *Tulasnei*; the mycelial characters, however, are those of the type.

U. aceris is not known to occur in America; the only record

* Eriksson, however, states that he has frequently observed both these plants growing together on *Acer platanoides* in nurseries at Stockholm.

of its occurrence there, by Harkness and Moore (159) rests on an error.

Eriksson states (119) that the present species causes much damage to young trees of *Acer* in the nurseries at Stockholm, and recommends as preventive measures the collection and burning of the diseased leaves.

The conidial stage of the present species was described as *Oidium aceris* Rabenh. Flora, **12**: 207. 1854.

var. **Tulasnei** (Fckl.) [Figs. 90–92]

Mucor Erysiphe Schrank, Prim. Fl. Salisb. 240 (partim). 1792.
Erysiphe bicornis Fr. Syst. Myc. **3**: 244 (partim). 1829.
Erysibe aceris Wahl. Fl. Suec. **2**: 1086. 1833.
Uncinula bicornis Lév. Ann. Sci. Nat. III. **15**: 135 (partim). 1851.
U. Tulasnei Fckl. Fung. Rhen. ur. 1746. 1866; Fckl. Symb. Myc. 81. 1869–70; Sacc. Syll. Fung. **1**: 9. 1882; Wint. in Rabenh. Krypt. Fl. Deutschl. 1^2: 41. 1884.

Exsicc.: Fckl. Fung. Rhen. 1746; Syd. Myc. March., 2835, *4232, and 2764 sub *U. bicornis;* Rab. Fung. Eur. 1915; * de Thuem. Myc. univ. 644, and Fung. austr. 1251; * Erikss. Fung. par. scand. 35.

Mycelium usually epiphyllous, very rarely amphigenous, persistent, densely compacted, forming either roundish circumscribed spots, or irregular blotches following the veins of the leaf, often becoming confluent and covering the upper surface of the leaf; perithecia subgregarious or scattered, globose-depressed to lenticular, 156–268 μ in diameter, averaging 205 μ; appendages numerous, ½–¾ diameter of the perithecium, simple or bifid, (usually mostly simple intermixed with a few bifid ones), colorless, smooth, thick-walled, with the lumen nearly or wholly obliterated in the lower part; asci 8–20, broadly ovate or elliptic-oblong, 64–98 × 40–50 μ, averaging 80 × 43 μ; spores 8, rarely 6 or 7, 26–30 × 14–17 μ.

Hosts.—Acer monspessulanum, A. platanoides, A. pseudo-Platanus (176) (210).

Distribution.—EUROPE: France, Germany, Switzerland (176), Austria-Hungary, Norway, Sweden, Russia.

U. aceris, var. *Tulasnei* is somewhat variable in the nature of its appendages; sometimes these are all simple, when there is a

certain resemblance to *U. salicis*, from which it is distinct in its large size, usually 8-spored asci, and thick-walled appendages; sometimes many of the appendages are bifid, when an approach is made towards the type. In *U. aceris*, however, although simple appendages do occur, these are always very few in number, and rarely, if ever, as numerous as in the var. *Tulasnei* (see, however, note above). Moreover, the densely compacted persistent mycelium is never found in *U. aceris* type.

Fuckel first separated the present plant as a distinct species (*U. Tulasnei*), and gave in the diagnosis the character "conidiis concatenatis, perfecte globosis, 8 mik. diametr." Subsequent authors have repeated the statement, and have relied on this character as the chief one for separating the plant. Thus Saccardo (307) says of *U. Tulasnei*, "Praecipue habitu et conidiis globosis dignoscenda species," and Winter (394, p. 42), "Unterscheidet sich von *U. aceris* hauptsächlich durch die kugeligen Conidien, die bei jener, wie bei allen anderen *Uncinula* arten elliptisch sind."

Eriksson (119, *pl. 4. f. 10–12*) figures these small globular conidia, and contrasts them with the much larger conidia of *U. aceris* proper.

Examination of herbarium material makes me doubt whether authors have been right in regarding these bodies as the conidia of the present plant. In certain specimens I have found, on the same leaf, the two kinds of conidia represented in Figs. 90–92. Fig. 90 is evidently the form described by the above authors (cf. Eriksson's figures); the conidiophores are very small, and with the small more or less globose spores (about 8 μ in diameter) bear no resemblance to the *Oidium*-form of other members of the *Erysiphaceae*. The other form (Fig. 91), present in about equal numbers agrees closely with the figures of the conidia and conidiophores of *U. aceris* given by Eriksson (loc. cit., *f. 7, 8*). It is possible that the small form is some species of *Oospora* associated accidentally with the *Uncinula*.

The mycelial characters, which give the present plant so different an appearance from the type, we know to be of very slight systematic value (cf. remarks on "*Erysiphe densa* Berk)," and other characters seem hardly important enough to give a higher than varietal rank under *U. aceris*.

as to how far the present plant has been confused with *U.* ... is almost impossible to say. Fries (130, p. 244) (1829) under *Erysiphe bicornis*, "Species in *Acere platanoide* ... ia eminus a reliquis dignoscitur maculis suis crustosis, contiguis, determinatis, sericeis, semper epiphyllis. ignis in nulla alia observatur." This evidently ap- *Tulasnei*. Léveillé, also (214), in 1851 included . under his *Uncinula bicornis*, as his description on p. 154 show: there is also a specimen of the var. in Berkeley's herbarium at Kew, named in Léveillé's writing *U. bicornis* (see also Tulasne (370, p. 197).

Acer platanoides is the usual host-plant for the present species, and on this tree it appears to be not uncommon on the Continent. It sometimes however occurs on *A. monspessulanum* (*A. trilobatum*), and Jaczewski (176) and Le Breton and Niel (210) have recorded it on *A. pseudo-Platanus.*

Eriksson (119, p. 7) records the present variety as often occurring with *U. aceris* on the same plant of *Acer platanoides*, and states that it causes great damage to this tree in the neighborhood of Stockholm, not only to young plants in nurseries, but also to large trees.

3. U. PRUNASTRI (DC.) Sacc. [Figs. 79, 80]

Erysiphe prunastri DC. Fl. Fr. **6**: 108. 1815; Tul. Sel. Fung. Carp. **1**: 199. 1861; de Bary, Beitr. Morph. Phys. Pilz. **1**: § xiii., 50. 1870.

Alphitomorpha adunca, var. *prunastri* Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 37. 1819.

A. prunastri Wallr. Ann. Wett. Ges. **4**: 237. 1819.

Erysibe adunca, var. *prunastri* Lk. Willd. Sp. Pl. **6**: 112. 1824.

Erysiphe adunca, var. *prunastri* Fr. Syst. Myc. **3**: 245. 1829; Duby, Bot. Gall. **2**: 870. 1830.

Alphitomorpha adunca, var. *rosacearum* Wallr. Fl. Crypt. Germ. **2**: 755 (partim). 1833.

Erysiphe adunca Fr. Kickx. Fl. Crypt. Erw. Louv., **139**: (partim). 1835.

Erysibe adunca, var. *rosacearum* Rabenh. Krypt. Fl. Deutschl. **1**: 236 (syn. excl. partim). 1844.

Uncinula Wallrothii Lév. Ann. Sci. Nat. III. **15**: 153. *pl. 7. f. 16.* 1851; Cooke, Handb. Brit. Fung. **2**: 647. 1871.

U. prunastri (DC.) Sacc. Syll. Fung. **1**: 7. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. 1^2: 41. 1884; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 245. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 742. 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 87. 1897.

EXSICC.: De Thüm. Myc. univ. 1450; Cooke, Fung. Brit. Exsicc. 217; ed. sec. 281; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 1306; *ed. 2, ser. 1, 706; Roumeg. Fung. Gall. Exsicc. 3649; Roumeg. Fung. Sel. Exsicc. 4928; Rab. Fung. Eur. 2133; Syd. Myc. March. 835, *3823; Fckl. Fung. Rhen. 1747; *de Thüm. Fung. austr. 463; *Sacc. Myc. Ven. 616; *Erb. Critt. Ital. ser. 2, 831 (cum *Podosphaera oxyacanthae* var. *tridactyla*); *Rab. Herb. myc. ed. 2, 758; *Erikss. Fung. par. scand. 140; Westend. Herb. Crypt. Belg. 969 (in Herb. Jard. bot. Bruxelles).

Amphigenous; mycelium evanescent; perithecia gregarious or scattered, very variable in size, from 80–146 μ in diameter, usually about 105 μ, globose-depressed, cells about 10 μ wide, somewhat translucent; appendages very variable in number, from 12–60, 1¼ to twice the diameter of the perithecium, rough (rarely smooth) and thick-walled below, thin-walled above, colorless, aseptate, slightly enlarged upwards to a simply uncinate apex measuring about 18 μ across; asci 7–18, ovate or elliptic-oblong, very shortly stalked, 42–58 × 24–30 μ; spores 5–7, 16–20 × 8–10 μ.

Hosts.—*Prunus insititia, P. pumila, P. spinosa* [*Crataegus* (338)].

Distribution.—EUROPE: Britain, France, Belgium, Netherlands (263), Germany, Switzerland (176), Italy, Austria-Hungary, Denmark, Norway, Sweden.

[ASIA: Transcaucasia (338)].

A very variable species in the size of the perithecium and number of the appendages. When the latter are few, *U. prunastri* recalls, by the rough base and enlarged apex of the appendages, *U. clandestina*, but that species is distinct in the 2–3-spored asci; when the appendages are numerous the present species approaches *U. salicis*, to which, of the European members of the genus, it is most allied, differing in the smaller perithecia and asci, the thick-walled and nearly always rough base of the appendages, and the smaller, usually 6-spores. The real affinity of *U. prunastri* is, however, with *U. Clintonii* (see remarks under that species).

U. prunastri has hitherto been recorded on a single host-plant, *Prunus spinosa*. I have, however, found examples contained in the Herbarium of the Upsala Museum, on *P. pumila*, and have also lately seen specimens growing on *P. insititia*, from France (Bagnères de Bigorre, Pyrenees, 2000′ J. H. Burkill, Aug., 1899).

There is a specimen, in Cooke's Herbarium, at Kew, labelled "*U. Wallrothii*, f. *Lonicerae Xylostei*, M. Cerva. Belluno. 18" in Professor Saccardo's handwriting. On the honeysuckle leaves there are certainly several perithecia of *U. prunastri*, but there is no evidence to show that these grew there. The perithecia appear to be all merely entangled in the leaf-hairs, and not fixed, and on the slight traces of mycelium present on the leaf I could find no signs of young perithecia.

Speschnew (338) records *U. prunastri* from Transcaucasia with the following note. "Le distingue du précédente [*U. salicis*] par 6 spores dans chaque ascus et a été trouvé sur une espèce de *Crataegus*, au parc de Tzinondaly, en septembre."

U. prunastri has been recorded from America, by E. C. Howe, in Cooke and Peck's "Erysiphei of the United States (91, p. 170), by Bessey (40, p. 7), and in Farlow and Seymour's Host-Index (125, p. 15), but the specimens referred to are all *U. necator;* the same is also the case with the specimen in Ravenel's Herbarium at the British Museum (S. Kensington) labelled "*U. Wallrothii* Lév. on *Ampelopsis*, Pennsylvania, Dr. Michener, ex Curtis."

4. U. CLANDESTINA (Biv. Bern.) Schroet. [Fig. 93]

Erysiphe clandestina Biv. Bern. Stirp. Rar. Sic. man. **3**: 20. *pl. 4. f. 4.* 1815.

Alphitomorpha adunca, var. *ulmorum* Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 37. 1819; Wallr. Fl. Crypt. Germ. **2**: 755. 1833.

Erysibe adunca, var. *ulmorum* Lk. in Willd. Sp. Pl. **6**: 112. 1824; Rabenh. Krypt. Fl. Deutschl. **1**: 236. 1844.

Erysiphe adunca Fr. Syst. Myc. **3**: 245 (partim). 1829.

E. ulmi Cast. Cat. Pl. Mars. **192**: 1845.

E. adunca, var. *ulmorum* Dur. & Mont., Fl. d'Algér. (Crypt.) **567**: 1846–9.

Uncinula Bivonae Lév. Ann. Sci. Nat. III. **15**: *pl. 7. f. 14.* 1851; Sacc. Syll. Fung. **1**: 6. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 40. 1884; Jacz. Bull. l'Herb. Boiss. **4**: 741. 1896.

Erysiphe Bivonae Tul. Sel. Fung. Carp. **1**: 200. 1861.

Uncinula clandestina (Biv. Bern.) Schroet.; Cohn's Krypt. Fl. Schles. **3**: 245. 1893.

EXSICC.: Rab. Fung. Eur. 2030; Fckl. Fung. Rhen. 698; Rehm. Ascom. 400; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 920, and *ed. 2, ser. 1, 220; Sacc. Myc. Ven. 617; de Thüm. Myc. univ. 755; Rab. Herb. Myc. ed. 2, 466; *Wartm. & Wint. Schweiz. Krypt. 824.

Amphigenous: mycelium evanescent, or subpersistent as a very thin effused film; perithecia closely gregarious in small patches, or scattered over the surface of the leaf, rounded-lenticular, 85–115 μ in diameter, averaging 95 μ, cells 10–14 μ wide: appendages few, 9–25, rarely 25–30, usually about 15, equalling or (usually) slightly exceeding the diameter of the perithecium, simple, colorless, aseptate, or occasionally septate near the base, thick-walled and usually rough below, thin-walled and swollen into a somewhat club-shaped apex above; asci usually 4, rarely 3, 5, or 6, broadly ovate to globose, with or without a very short stalk, 40–45 × 32–40 μ, averaging 45 × 35 μ; spores 2, very rarely 3, 30–34 × 15–18 μ, sometimes slightly curved.

Hosts.—Ulmus campestris, U. montana.

Distribution.—EUROPE: England (239), France, Belgium (209), Germany, Switzerland, Italy, Austria-Hungary, Poland.

AFRICA: Algeria.

ASIA: Japan.

A well-marked species in the few, somewhat club-shaped appendages and the 2-spored asci.

U. clandestina is not known to occur in America, all the records of its occurrence in the United States being erroneous, and mostly referring to *U. macrospora.* The plant recorded as *U. Bivonae* by Cooke and Peck (90, p. 11) is *U. Clintonii*, and the host-plant is *Tilia Americana*, not *Ulmus* as stated. The claim of *U. clandestina* to be considered as British rests on the authority of Cooke, who records (239) this species as growing on the elms in the Royal Gardens, Kew; I cannot, however, find specimens from this locality in this author's herbarium at Kew. The African

(Algerian) specimen is in Montagne's herbarium in the herbarium of the Paris Museum. The Japanese example (now in the Kew Herbarium), on *Ulmus campestris*, was sent to me by Prof. Miyabe, and agrees perfectly with European specimens. This is the first record of *U. clandestina* from Asia.

5. U. NECATOR (Schwein.) Burr. [Fig. 86]

Erysiphe necator Schwein. Syn. Fung. Am. Bor. 270. 1834; Sacc. Syll. Fung. 1: 22. 1882.

E. Tuckeri Berk. Journ. Hort. Soc. Lond. 9: 66. 1855; de Bary, Beitr. Morph. Phys. Pilz. 1: § xiii. 50. 1870; Sacc. Syll. Fung. 1: 20. 1882; Wint. in Rabenh. Krypt. Fl. Deutschl. 1^2: 34. 1884.

Sphaerotheca Castagnei, var. *vitis* Fckl. Symb. Myc. 79. 1869–70.

Uncinula Americana E. C. Howe, Journ. of Bot. II. 1: 170. 1872; Sacc. Syll. Fung. 1: 8. 1882.

U. spiralis Berk. & Curt. Grevillea, 4: 159. 1876; Atkins. Journ. Elisha Mitch. Sci. Soc. 7: 66. 1891; Jacz. Bull. l'Herb. Boiss. 4: 739. 1896.

U. subfusca Berk. & Curt. Grevillea, 4: 160. 1876.

U. spiralis, var. *racemosum* Thüm. Pilz. des Weinst. 12. 1878.

U. ampelopsidis Peck, Trans. Albany Inst. 7: 216. *f. 16–18.* 1872; Peck, Reg. Rep. 25: 96. 1873; Sacc. Syll. Fung. 1: 7. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. 2: 406. *f. 5.* 1887.

U. necator (Schwein.) Burr.; Ell. & Ever. N. Amer. Pyren. 15. 1892.

Erysibe Tuckeri (Berk.) Schroet.; Cohn's Krypt. Fl. Schles. 3: 241. 1893.

EXSICC.: Rab.-Wint. Fung. Eur. 3745; Ellis, N. Amer. Fung. 133; de Thuem. Myc. univ. 1143, 19, 38; Roumeg. Fung. sel. Exsicc. 4757; * Seym. and Earle, Econ. Fung. 4, 5; * Ell. and Everh. Fung. Columb. 415; * de Thuem. Pilz. des Weinst. 5.

Amphigenous, mycelium usually subpersistent, very thin and effused, or forming circumscribed patches, sometimes evanescent: perithecia usually epiphyllous, sometimes hypophyllous, occasionally occurring on the inflorescence, globose-depressed, more or less scattered, 70–128 μ in diameter, averaging 98 μ, cells distinct,

rather irregular in shape, 10–20 μ wide, appendages very variable in number and length, 7–32, rarely irregularly crowded and as many as 40, 1–4 times the diameter of the perithecium, smooth, simple, septate, thin-walled, light or dark amber-brown in the lower half, flexuous and flaccid when long, subrigid and straight when shorter, apex more or less helicoid when mature, often strongly so: asci 4–6, rarely 6–9, broadly ovate or ovate-oblong to subglobose, with or without a short stalk, 50–60 × 30–40 μ; spores 4–7, 18–25 × 10–12 μ.

"Hyphasma, tenuissimum album, floccis valde tenuibus, orbiculatum, non constringens. Sporangiolis minutissimis, raris, fusco-nigris, globosis. Ubi omnino evoluta, etiam haec species destruit uvas . . . in uvis *Vitis Labruscae* varietatibus cultis in vineis nostris" (Schwein, *loc. cit.*).

Hosts.—*Actinidia arguta*, *A. Kolomikta*, *A. polygama*, *Ampelopsis cuspidata* (60), *Vitis aestivalis* (60), *V. Californica* (373), *V. cordifolia* (97) (249), *V. flexuosa*, *V. hederacea* (*Ampelopsis quinquefolia*), *Vitis Labrusca* and var. *Catawba*, *V. riparia* (60), *V. rupestris* (373), *V. vinifera*.

Distribution (of perithecial form only).—EUROPE: France.

ASIA: Japan.

NORTH AMERICA: United States—Maine, Massachusetts, New York, Pennsylvania, Maryland, New Jersey, West Virginia (249), Ohio, Michigan, Indiana, Alabama (12), Illinois, Mississippi, Wisconsin, Missouri, Iowa, Kansas, Texas (373), New Mexico, South Dakota (151), California. Canada—Ontario.

Uncinula necator is at once known by the colored appendages, which are, however, very variable in number and length.

The form on *Vitis hederacea* (*Ampelopsis quinquefolia*) is the *Uncinula ampelopsidis* of Peck (*U. subfusca* Berk. and Curt.) and at first sight seems to be distinct in the shorter, fewer (7–22) appendages, 1–3, usually 1½ times the diameter of the perithecium, not flexuous nor flaccid, and distinctly wider both in the lower half (7–8 μ wide), and towards the apex (8–10 μ). These characters are shown by most forms on this host-plant, and were they confined to this might entitle the plant to a varietal rank. But, as most American mycologists now admit, they are not so. In the ordinary examples of *U. necator* on *Vitis Labrusca*, *V. vinifera*, etc., the long appendages are about 5 μ wide, flexuous and weak, but

in the forms where the appendages tend to become shorter they also immediately become wider, more rigid, and less flexuous, and one is finally forced to the conclusion that "*U. ampelopsidis*" is but the last member of a chain of closely connected forms.

The occurrence of *U. necator* on species of *Actinidia*—a genus of plants belonging to Ternstroemiaceae, an order in no way related to Vitaceae—is very interesting, not only because the vine mildew has hitherto been supposed to be confined to vines, but also for the evidence it gives on the question, mentioned below, of the native country of *U. necator*. Professor Miyabe sent me numerous specimens (now in the Kew Herb.) of this form from Japan as "*Uncinula actinidiae*" Miyabe mss., but on examination the specimens proved to agree well with certains forms of *U. necator* from America. Some of the Japanese specimens have perithecia with few (about 8), short, wide appendages, 1–1½ times the diameter of the perithecium; others have more numerous, sometimes irregularly crowded appendages, up to 28 in number, flaccid and three times the diameter of the perithecium. These Japanese specimens further strengthen the view that no sharp line can be drawn between the long- and short-appendaged forms of the present plant. Some of the appendages of the Japanese specimens show a distinctly swollen base (Fig. 86). The apex of the appendages, when mature, is strongly helicoid.

U. necator, or "*Oidium Tuckeri*" as the conidial stage has long been called in Europe, is well known as the vine mildew, a disease which has caused the most serious injury to cultivated vines in both the Old and the New World. The literature concerning "*Oidium Tuckeri*," dealing with its systematic position, until quite recently a matter of doubt, its appearance, mode of attack, remedies, etc., is so vast that only a few references to the most important works can be given here. Briefly, the history of this vine mildew is as follows: In 1847 Berkeley (27) wrote in the Gardeners' Chronicle that "The grapes in the neighborhood of Margate (England) have for the two last years been attacked by a peculiar mildew of a most destructive character." Berkeley named the fungus *Oidium Tuckeri*, but even here hinted of its connection with an *Erysiphe*. The disease appeared almost immediately in all the vineyards of the Mediterranean region, and by 1851 it had been

observed in France, Switzerland, Germany, Italy, Asia Minor, Syria, Algeria, etc.; in 1852 it caused wholesale destruction in Madeira; in 1866–7 it was recorded from Australia; it is common throughout the United States, has lately occurred in Brazil and has been reported on vines in Japan; it is now, in fact, a disease almost certain to appear wherever grapes are grown.

Fortunately, a cheap and reliable remedy has been found against the vine mildew in the form of sulphur (flowers of sulphur, or solutions of the sulphide), and the disease is now held completely in check by means of the use of this fungicide. Galloway (137) (138) recommends the following method: In applying the sulphur, bellows should be used, and the first applications should be made ten or twelve days before the flowers open, the second when in full bloom, and a third three weeks or a month later if the disease seems to be on the increase. The best results are obtained when the applications are made with the thermometer ranging from 80° to 100° F. In this temperature fumes are given off, which quickly destroy the fungus. We have obtained excellent results in treating this disease with a solution made by dissolving half an ounce of potassium sulphide to the gallon of water. (In preparing the solution, half an ounce of the "liver of sulphur" was dissolved in one pint of hot water; as soon as dissolved, the cold water (1 gallon less 1 pint) was poured with the hot solution, and the whole immediately strained through a thick osnaburg cloth into a tin can and closely stopped.) This preparation is cheap and can be quickly and effectually applied with any of the well-known spraying pumps. The greatest care should be exercised in making the second spraying, which should be at the same time as that mentioned for the flowers of sulphur, in order to protect the blossoms from the fungus. For other preparations, and their method of application, etc., reference may be made to Viala (373).

It is important to distinguish clearly between the two diseases that have been called the "vine disease" or "vine mildew," the one due to the attacks of "*Oidium Tuckeri*," the other to those of *Peronospora viticola*, as the remedies for the latter (Bordeaux mixture, l'eau céleste, sulphate of copper) have been found to be of no effect against *Oidium Tuckeri*. It is therefore well to adopt the

distinctive names proposed by Riley for these two diseases, and now generally in use in America, viz., powdery vine mildew for *U. necator* (*Oidium Tuckeri*) and downy vine mildew for *Peronospora viticola.*

Although *Oidium Tuckeri* was so terribly prevalent in Europe since its appearance in 1845–6, no perithecia were found associated with it for the first 47 years of its occurrence, and during this time its true systematic position was much questioned. Berkeley (32), recognizing its close resemblance to the conidial stage of species of *Erysiphe*, changed the name in 1855 to *Erysiphe Tuckeri.* When, however, the *Uncinula* on the American vines became generally known, it began to be suggested that "*Oidium Tuckeri*" might be merely the conidial stage of this fungus; and Farlow (121) and Viala and Ravaz (375) among others pointed out the exact resemblance of the American and European *Oidium* forms. Many mycologists, however, would not admit the identity of the two, contending that the *Oidium Tuckeri* of the Old World had larger conidia than those of the American *U necator.* Fuckel considered *Oidium Tuckeri* to be the conidial condition of a variety of *Sphaerotheca Castagnei;* whilst others believed it to be that of *Erysiphe communis* (*E. polygoni*). In 1844 Berkeley recorded (37) the occurrence of a species of *Erysiphe*, apparently identical with *E. communis*," growing with *U. necator* on Vine leaves sent from Washington. [This was probably either a stray perithecium of *E. polygoni*, or probably immature examples (with young straight appendages) of *U. necator.*] However, in 1892 Couderc (93) discovered in several places in France, perithecia on vines attached by "*Oidium Tuckeri*," and showed that they were identical with those of *U. necator.* In the following year Viala (1894) reported an abundant formation of perithecia of *U. necator*, or diseased vines in many parts of France. This unusual production of the perithecial stage has been attributed to the sudden alternation of high and low temperatures which took place in these years. Through the kindness of Mr. Jaczewski I have seen specimens (now in the Kew Herbarium) of French examples of *U. necator* and have found them to agree in every way with American examples of this species.

Mycologists, *e. g.*, de Bary, von Mohl, Viala, Worthington G.

Smith—have considered that "*Oidium Tuckeri*"—the conidial stage of *U. necator*—was originally brought from the vines of America to Europe, and thus introduced at once spread over all the Mediterranean vineyards, but that from some cause due to the effect of the change of environment, the fungus lost the power of producing perithecia. Several fungous diseases are now known to have been introduced in this way from America to Europe, and so long as America was the only native country known for *U. necator*, the idea of the American origin of "*Oidium Tuckeri*" was natural, although it appears that no direct evidence on the point exists; now, however, that we know that *U. necator* is native to the Old World, occurring on native plants in Japan, it is a question whether it may not have invaded Europe from the East. *Vitis vinifera* is wild in western temperate Asia (and perhaps in the Mediterranean region), being especially frequent in Armenia, Caucasia, and the region round the Caspian Sea, and it is possible that *U. necator* will be found to occur in wild vines in these countries. It is, of course, possible that "*Oidium Tuckeri*" existed on European vines before the great outbreak of it in 1847–52—and there is some evidence favorable to this view—but that, at this time, for some unknown reason it first increased to such an extent as to form a dangerous disease. (For further details of the history of "*Oidium Tuckeri*" reference can be made to the following authors: Viala (373), von Mohl (250, 251, and 252) and Montagne (254).

As it appears that the formation of perithecia is exceptional in *U. necator* on European vines, the question presents itself as to how the fungus, in this absence of ascospores, bridges over the period of winter. It has been stated this is effected by a hibernating mycelium; other authors, *e. g.*, Viala, suppose that the conidia have acquired the power of being able to hibernate.

It is worth noting that Viala tried many experiments with the view of seeing if vines could be infected with the conidia of *Erysiphe polygoni*, and conversely, if the host-plants of *E. polygoni* could be attacked by "*Oidium Tuckeri*," but with negative results in both cases.

Galloway (139) has made some valuable observations on the ripening of the perithecium and the germination of the ascospores of the present species. Infected leaves of *Ampelopsis* and *Vitis*

were placed in the autumn in sacks on the open ground. Although the appendages of the perithecium soon disappeared, the asci and spores underwent little change until the end of December, when many of them were found to be dead or more or less collapsed. All attempts to germinate the ascospores before January failed, and it was only after repeated trials through February and March that success was attained. The perithecia were from time to time removed from the leaves and placed in a drop of sterile water in Van Tieghem cells. In one instance, which may be taken as typical of the usual development, some perithecia were placed in cells on January 7th. Twenty days later no change had taken place, the cell having been kept free from jars. The cell was then placed under the microscope, and gently jarred with a needle, whereupon one of the perithecia suddenly burst and the asci escaped into the surrounding water. The first ascus was violently ejected from the perithecium to a distance equal to about twice the length of the former. This was immediately followed by a second and a third ejected in the same way. The ruptured wall of the perithecium then closed and no more asci escaped. No sooner were the asci free than their spores began to escape or else to break up within the ascus. In the former case they escaped from the top, side or bottom of the ascus. A large part of the spores burst as soon as they were set free. Nearly all the spores that failed to burst began to send out germ tubes in four or five hours, and at the end of twelve hours the tubes had reached a length twice that of the spore or more. A number of attempts were made to infect leaves with ascospores, but the results were in every case negative.

6. U. CIRCINATA Cooke & Peck

U. circinata Cooke and Peck, Journ. of Bot. II. **1**: 12. 1872; Peck, Trans. Albany Inst., **7**: 214. *f.* 7–9. 1872; Peck, Reg. Rep. **25**: 96. 1873; Sacc. Syll. Fung. **1**: 8. 1882; Burr and Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 408. 1887; Burr.; Ell. & Everh. N. Amer. Pyren. 17. 1892.

EXSICC.: Ell. N. Amer. Fung. 427; de Thüm. Myc. Univ. 2051; Roumeg. Fung. select. exsicc. 4927; Ell. and Everh. Columb. Fung. 110; *Seym. and Earle, Econ. Fung. 115, 116.

Hypophyllous, rarely amphigenous; mycelium evanescent, or subpersistent on the upper surface of the leaf and sometimes forming definite spots; perithecia usually scattered, sometimes gregarious, rounded-lenticular, 160–225 μ in diameter, rarely only 125–160 μ, averaging 190 μ, cells obscure, irregular, 10–14 μ wide; appendages very numerous, usually densely crowded, just falling short of the diameter of the perithecium, simple, smooth, aseptate, rather delicate, about 5 μ wide, thin-walled and hyaline throughout, apex simply uncinate; asci 9–26, usually about 15, narrowly ovate or cylindrical, sometimes ovate-oblong, with or without a short stalk, 68–86 × 29–40 μ; spores 8, sometimes 7, 18–22 × 10–14 μ.

Hosts.—*Acer dasycarpum*, *A. Pennsylvanicum* (60), *A. rubrum*, *A. saccharinum*, *A. spicatum*.

Distribution.—NORTH AMERICA: United States—Maine (163), Vermont, Massachusetts, New York, Pennsylvania, South Carolina Ohio, Michigan, Indiana, Alabama, Illinois, Wisconsin, Missouri (363), Iowa. Canada—Ontario.

"This species is related to *U. bicornis* [*U. aceris*], from which it is distinguished by its hypogenous habit, more numerous sporangia and always simple appendages. It usually occupies the whole under-surface of the leaf." (Peck, 25 Rep.)

This distinct and endemic species, which apparently takes the place of the European *U. aceris* on the maples of North America, is somewhat intermediate between *U. aceris* and *U. salicis*, agreeing with the former species in the 8-spored asci and large perithecia, and with the latter in the numerous, simple, thin-walled appendages. From *U. aceris*, var. *Tulasnei* it differs in the more or less evanescent mycelium, and thin-walled appendages. When well-developed the appendages cover the whole of the upper half of the perithecium.

7. U. PARVULA Cooke & Peck

U. parvula Cooke & Peck, Journ. of Bot. II. 1: 170. 1872; Burr & Earle, Bull. Ill. State Lab. Nat. Hist. 2: 409. 1887; Sacc. Syll. Fung. 9: 367. 1891; Atkins. Journ. Elisha Mitch. Sci. Soc. 7: 67. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 18. 1892.

U. Torreyi Gerard, Trans. Albany Inst. 7: 215. 1872.

Amphigenous; mycelium evanescent; perithecia usually hypophyllous, scattered, globose-depressed, small, 86–122 μ in diameter, averaging 98 μ, cells about 10 μ wide; appendages numer-

ous, 50–160, ½–¾ the diameter of the perithecium, simple, colorless, aseptate, becoming more or less thick-walled throughout, smooth, delicate, 3–4 μ wide, slightly attenuated upwards, apex simply uncinate; asci 5–8, broadly ovate with or without a short stalk, 50–64 × 34–38 μ; spores 4–7, usually 6, 20–24 × 10–12 μ.

Hosts.—*Celtis Americana, C. occidentalis.*

Distribution.—NORTH AMERICA: United States—New York, New Jersey, South Carolina, Indiana, Alabama (12), Illinois, Mississippi, Missouri, Iowa, Kansas (386), Washington. "From the Atlantic coast to Washington; not apparently abundant, but often collected from widely separated localities" (Burrill (60)).

An interesting species (endemic to North America), distinct from *U. salicis* in the small perithecia with shorter, more delicate and narrower appendages, which become more or less solid through obliteration of the lumen at maturity.

8. U. MACROSPORA Peck

U. macrospora Peck, Trans. Albany Inst. **7**: 215. *f. 4–6.* 1872; Peck, Reg. Rep. **25**: 96. 1873; Sacc. Syll. Fung. **1**: 7. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 407. 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 66. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 18. 1892.

U. intermedia Berk. & Curt. Grevillea, **4**: 160. 1876; Sacc. Syll. Fung. **1**: 7. 1882.

EXSICC.: Ell. N. Amer. Fung. 426; de Thüm. Myc. Univ. 2053; Rab.-Wint. Fung. Eur. 3244; *Seym. & Earle, Econ. Fung. 154, 156a, 156b; *Ell. & Everh. Fung. Columb. 223, 414.

Amphigenous; mycelium evanescent, or subpersistent and pruinose, rarely forming circumscribed patches on the upper surface of the leaf; perithecia closely gregarious in small patches, or scattered over the surface, globose-depressed or lenticular, 95–165 μ in diameter, averaging 130 μ, cells about 10 μ wide; appendages numerous, 50–130 or more, varying in length from ⅓ the diameter of the perithecium to a little more than its diameter, smooth, colorless, aseptate, simple, thick-walled at base, thin-walled above, not or scarcely enlarged upwards, apex usually simply uncinate, but sometimes subhelicoid; asci 8–14, rarely 14–20, sub-pyriform or elliptic-oblong, often curved, 54–65 × 29–35 μ; spores 2, 30 × 15–18 μ.

Hosts.—Ostrya Virginica, Ulmus alata, U. Americana, U. fulva.

Distribution.—NORTH AMERICA: United States—Massachusetts, New York, North and South Carolina, Ohio, Michigan, Indiana, Alabama, Illinois, Mississippi, Wisconsin, Missouri (363), Iowa, Kansas, South Dakota (151).

Quite distinct from *U. Bivonae*, its nearest ally, in the larger perithecia, with more numerous appendages and asci. *U. Bivonae* is frequently recorded as occurring in America, but this is incorrect, and the specimens so named have proved (with one exception) to belong to the present species.

9. U. FLEXUOSA Peck. [Figs 83, 84]

U. flexuosa Peck, Trans. Albany Inst. **7**: 215. *f. 10–12.* 1872; Sacc. Syll. Fung, **1**: 8. 1882; Burr & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 408. 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 66. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 16. 1892.

EXSICC.: de Thüm. Myc. Univ. 2052; Ell. N. Amer. Fung. 661; Rab.-Wint. Fung. Eur. 3658; *Seym. & Earle, Econ. Fung. 118a, 118b; *Ell. & Everh. Fung. Columb. 416.

Hypophyllous, or sometimes amphigenous; mycelium evanescent or under surface of leaf, but sometimes subpersistent in very thin patches on the upper surface; perithecia more or less scattered, rounded-lenticular, 85–156 μ in diameter, averaging 100 μ, cells distinct, averaging 17 μ wide; appendages variable in number, 14–60, usually about 30, about equalling the diameter of the perithecium, simple, colorless, and aseptate, hyaline, enlarged, and abruptly flexuose upwards, becoming refractive and thick-walled, and often rough below; asci 4–11, broadly ovate, with a short stalk, 50–58 × 30–38 μ; spores usually 8, sometimes 7 or (rarely) 6, 18–22 × 10 μ.

"The flexuose appendages are characteristic of this species. They sometimes appear as if twisted like the blade of a screw-auger" (Peck, loc. cit.).

Hosts.—Aesculus arguta (386), *A. flava* (60), *A. glabra, A. Hippocastanum, A. Pavia.*

Distribution.—NORTH AMERICA: United States—Massachusetts, New York, New Jersey, South Carolina, Ohio, Indiana, Alabama, Illinois, Mississippi (361), Missouri, Kansas (386). Canada—Ontario.

Very variable in the size of the perithecia and number of the appendages, but easily recognized by the abruptly undulated upper half of the appendages (Fig. 83) and the usually 8-spored asci.

Saccardo's description of *U. flexuosa*, "peritheciis 80–90 μ d., appendicibus 15–25" applies only to the small form of the species, such as, for instance, the specimen in the Kew Herbarium from South Carolina ("C. H. P., 192"), where the perithecia are frequently only 90 μ in diam., with 25 or fewer appendages. Peck and Saccardo compare *U. flexuosa* with *U. salicis*, but there is no close relationship between these two species, and it is *U. Clintonii* that is undoubtedly the nearest ally to the present species. The small forms of *U. flexuosa*, mentioned above, approaches certain examples of *U. Clintonii* very closely, and can only be separated by the—in this form—slightly-undulated appendages, which are shorter, and by the 8-spored asci.

10. U. CLINTONII Peck. [Figs. 81, 82]

U. Clintonii Peck, Trans. Albany Inst. **7**: 216. *f. 13–15.* 1872; Peck, Reg. Rep. **25**: 96. 1873; Sacc. Syll. Fung. **1**: 7. 1882; Burr.; Ell. & Everh. N. Amer. Pyren. 15. 1892.

EXSICC.: Ell. N. Amer. Fung. 662; *Seym. & Earle, Econ. Fung. 105; *Rab.-Wint.-Pazsch. Fung. eur. 4051; *Ell. & Everh. Fung. Columb. 413.

Hypophyllous, or amphigenous; mycelium usually evanescent, sometimes sub-perisistent; perithecia gregarious or scattered, 80–130 μ in diameter, rarely only 64–86 μ (on *Zelkova*), cells rather irregular in shape, 10–20 μ wide; appendages 10–35, or rarely as few as 7, usually about 20, 1–2, rarely 2½ times the diameter of the perithecium, often unequal in length on the same perithecium, simple, colorless or sometimes brownish-amber at base, refractive, thick-walled and often rough below, smooth, thin-walled and swollen above, measuring 20–30 μ across the simply uncinate clavate apex; asci 4–10, or 2–4, usually 3 (on *Zelkova*), broadly ovate to subglobose, very shortly stalked, 40–62 × 34–40 μ.; spores 3–7, usually 5–6, more or less crowded in the ascus, 20–25 × 10–13 μ.

Hosts.—*Aphananthe aspera, Tilia Americana, Zelkova acuminata.*

Distribution.—ASIA: (on *Aphananthe* and *Zelkova*) Japan.

NORTH AMERICA: (on *Tilia*) United States: New York, Maryland, Ohio, Michigan, Indiana, Illinois, Wisconsin, Iowa, Minnesota. Canada—Ontario.

This species shows great affinity with the European *U. prunastri*, from which it differs in the usually fewer and always broader asci, larger spores, and usually more swollen apex of the appendages. With regard to the last character, however, there is certainly much variation, as a glance at Fig. 81 will show, and it would be unsafe to place any great value on this point.

U. Clintonii has been hitherto regarded as confined to North America, where it occurs not unfrequently on the single host-plant, *Tilia Americana*. Among the Japanese specimens of Erysiphaceae, however, sent to me by Professor Miyabe there occurs an *Uncinula*, which, although differing slightly from the American examples must, I think, be included under the present species. Two specimens were sent, one on *Zelkova acuminata* (*Z. Keaki*) from Kobe, (K. Miyabe, Aug. 1889), the other on *Aphananthe aspera* from Tokyo (K. Sengoku, Oct. 1898).

The first specimen sent was that on *Zelkova*, and as this differed in several characters from the American form, I was at first inclined to rank it as a variety *minor* under *U. Clintonii*. The specimens showed these characters: mycelium epiphyllous, subpersistent, very thin, effused; perithecia uniformly scattered over the upper surface of the leaf, small, 64–86 μ in diameter, averaging 78 μ, cells 10–20 μ wide; appendages 12–25, unequal in length, from equalling to twice exceeding the diameter of the perithecium, colorless, simple, thick-walled, refractive and narrow (about 4 μ wide) at the base, thin-walled and enlarged upwards, about 20 μ wide across the simply uncinate apex; asci 2–4, usually 3, 40–50 × 34–40 μ, subglobose, with or without a very short stalk; spores 3–5, crowded in the ascus, 20–24 × 10–12 μ.

This "var. *minor*" could be thus contrasted with the American plant: *U. Clintonii* (American); perithecia 80–130 μ in diameter, appendages 22–30 μ wide across the apex, asci 4–10. "Var. *minor*" (Japanese); perithecia 64–86 μ in diameter, appendages about 20 μ wide across the apex, asci 2–4, usually 3.

The second Japanese specimen sent (on *Aphananthe*), however, broke down these distinctions, as this form has perithecia 75–

100 μ in diameter, appendages 20 μ wide across the apex, and from 3 to 6 asci. In the American examples the appendages vary from 10 to 35 in number, and are usually about 20, and are from 1 to 2, or even 2½ times the diameter of the perithecium; in the Japanese example on *Aphananthe* the appendages vary from 7 to 18, and are usually about 12, and equal or slightly exceed the diameter of the perithecium. They are also, as a rule, slightly wider at the base than is usually the case in American *U. Clintonii*.

Both the Japanese specimens agree with *U. Clintonii* in the small subglobose asci, and spores distinctly larger than those of *U. prunastri*, and it seems best therefore, so long as *U. Clintonii* and *U. prunastri* are maintained as distinct species to regard the Japanese plants as belonging to the former species. It may be pointed out that these forms on *Zelkova* and *Aphananthe* differ just as slightly from one another, as either of them does from typical *U. Clintonii*.

11. U. GENICULATA Gerard

U. geniculata Gerard, Bull. Torr. Club, **4**: 48. 1873; Sacc. Syll. Fung. **1**: 8. 1882; Burr.; Ell. & Everh. N. Amer. Pyren. 19. 1892.

EXSICC.: Rab.-Wint.-Pazsch. Fung. Eur. 3955; *Seym. & Earle, Econ. Fung. 152.

Epiphyllous; mycelium thin, arachnoid, forming definite patches, or more or less effused, sometimes evanescent; perithecia subgregarious on the patches, or scattered, small, 90–120 μ in diameter, usually about 100 μ, globose-depressed, cells rather irregular, 10–15 μ wide; appendages 24–46, 1¼ to twice the diameter of the perithecium, delicate, 3–4 μ wide, some usually abruptly bent or geniculate, simple, colorless, aseptate, thin-walled, smooth or minutely rough at base, apex simply uncinate: asci 5–8, broadly ovate, very shortly stalked, 48–56 × 34–38 μ: spores 4–6, 22 × 12 μ.

Host.—*Morus rubra*.

Distribution.—NORTH AMERICA: United States—New York (144), Indiana, Alabama, Illinois, Missouri, Kansas.

This species approaches slightly certain forms of *U. salicis*, but is distinct in the smaller perithecia, with fewer delicate narrower appendages, which are not enlarged but usually slightly attenuated upwards. In *U. salicis* the appendages are, as a rule, much

more numerous, and always stouter and wider (5–7 μ wide). Moreover, in most perithecia of *U. geniculata* at least one or two of the appendages show an abrupt geniculate bend, and this character, when present, is quite sufficient to distinguish the present plant from all the species of *Uncinula* except some forms of *U. salicis*, var. *Miyabei*, and from this variety *U. geniculata* differs in the much narrower appendages, not enlarged upwards. Sometimes, however, all the appendages are straight, and *U. geniculata* is then best known by the rather few, delicate, narrow appendages. The asci are described as being 6-spored, but they are frequently 4-spored. The fewer and much longer appendages at once separate the present plant from *U. parvula.*

U. geniculata is confined to the United States; the record by Issatchenko (171) of its occurrence in Russia rests on an error.

Among the specimens of Erysiphaceae sent to me from the Herbarium of the U. S. Department of Agriculture was one labelled "*Erysiphe cichoraccarum* DC. On *Hydrophyllum appendiculatum.* Crawfordsville, Indiana. E. M. Fisher, Oct., 1890. No. 1003." This specimen showed, on examination, only perithecia of a species of *Uncinula* scattered irregularly over the surface of the leaf. Feeling doubtful if this *Uncinula* really originated on this host-plant, I wrote to Professor Galloway on the subject, who replied, "I regret to state that we are unable to give you any information in regard to the care of the material labelled *E. cichoraccarum* on *Hydrophyllum appendiculatum.* It has for some years been in mycological envelopes, labelled as above, and whether it was previously in contact with any host bearing *Uncinula*, it is now impossible to ascertain. Nothing but perithecia of *Uncinula* appear to be upon several specimens examined to-day, and we are fearful that the first determination was an error." After a careful comparison of the perithecia, I found them to agree in all characters with those of the present species—*U. geniculata*—which has been recorded only on *Morus rubra.* The leaves of the *Hydrophyllum* show patches of mycelium on the upper surface, and on these as well as on parts of the leaf without mycelium, the perithecia of *U. geniculata* are scattered. These perithecia appear more or less loose, and can be easily lifted off with a needle, and I was not able to observe any connection with the mycelium, nor the occurrence of

any young perithecia. On the whole, it must be left doubtful for the present, for reasons stated in the preface whether *Hydrophyllum appendiculatum* is really a host-plant of *U. geniculata*. I have gone fully into the above case because it affords an exact parallel to that of the single occurrence of *U. salicis* on *Scutellaria lateriflora*.

12. U. POLYCHAETA (Berk. & Curt.) ex. Ellis. [Fig. 89]

Erysiphe polychaeta Berk. & Curt. Grevillea, **4**: 159. 1876.

Uncinula Lynchii Speg. Fung. Argent. Pug. **2**: 17, 44. 1880.

Pleochaeta Curtisii Sacc. & Speg., Sacc. Michelia **2**: 373. 1881; Sacc. Syll. Fung. **1**: 9 (partim). 1882 & Addit. ad vols. 1–4: 2. 1886.

Uncinula polychaeta (Berk. & Curt.) ex. Ellis in Journ. Myc. **2**: 43. 1886; Tr. & Gall. Bot. Gaz. **13**: 29 syn. excl. partim. (cum icon.) 1888; Massee, Grevillea, **17**: 78. 1889; Sacc. Syll. Fung. **9**: 367. 1891; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 67. *pl. 1. f. 5, 11.* 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 18. 1892.

EXSICC.: Rav. Fung. Carol. Exsicc. fasc. 4, 68 & Ell. & Everh. N. Amer. Fung. 2113, sub *U. polychaeta* Berk. & Curt.; *Seym. & Earle, Econ. Fung. 149; *Speg. Dec. Myc. Argent. 39.

Hypophyllous; mycelium dense, forming irregular whitish patches, or completely evanescent; perithecia gregarious on the patches of mycelium, or when these are absent, scattered over the surface of the leaf; rounded-lenticular, very large, 215–320 μ in diameter, averaging 255 μ, cells obscure, appendages very numerous, usually about 200, closely crowded, $\frac{1}{4}$–$\frac{2}{3}$ the diameter of the perithecium, smooth, thick-walled with the lumen more or less completely obliterated, simple, colorless, narrowed upwards to the closely uncinate apex, aseptate; asci very numerous, 34–66, cylindrical or subcylindrical, rarely oblong, more or less abruptly attenuated into an evident stalk, 70–84 × 20–26 μ; spores 2–3, (very rarely 4), 26–30 × 12–14 μ.

Hosts.—*Aphananthe aspera*, *Celtis occidentalis*, *C. tala*, *C. Mississippiensis*, *Celtis* sp. (Chinese).

Distribution.—ASIA: China (Yunnan), Japan.

NORTH AMERICA: United States—South Carolina, Alabama, Mississippi.

SOUTH AMERICA: Argentine (Buenos Ayres).

Very distinct in the large perithecia—the largest in the genus —the closely crowded short appendages, more or less attenuated upwards into the small closely involute apex, and the very numerous 2–3-spored asci.

U. polychaeta has been recorded hitherto only from America, but specimens sent to me as "*Uncinula adunca* Lév. sur *Celtis*, Yunnan, China '(leg. Delavay)," by M. Patouillard prove to belong to the present species, and so give an interesting extension to the range of this species hitherto supposed to be endemic to America. Whilst agreeing in all other respects, the Chinese specimens differ in having asci which are regularly 3-spored; in American examples the asci, in my experience, are nearly always 2-spored, with rarely a rudimentary third spore present. Tracy and Galloway (362), however, in their remarks on the American plant, say "spores usually two, oval, subhyaline, nearly filling the ascus. Sometimes three or even four spores are found in an ascus. When three occur in an ascus, two are of nearly the usual size, and the third quite small, and when four occur all are small." It would thus obviously be unsafe to separate in any way the Chinese from the American plant.

Since the above remarks were written Prof. Miyabe has sent me a plant named "*Uncinula* n. sp. related to *U. polychaeta*, but trisporous. On *Aphananthe aspera*, Tokyo, Japan, October 29, 1895 (K. Sengoku)." In this Japanese example most of the asci are 3-spored, although they may be frequently found only 2-spored, and the fungus is evidently to be referred to *U. polychaeta*.

It is necessary to keep the specific name *polychaeta* for the present species. It was described as *Erysiphe polychaeta* Berk. & Curt. and stands first on the same page where *Uncinula polychaeta* Berk. & Curt. was published. The latter species has been renamed *U. confusa* by Massee.

The genus *Pleochaeta* Sacc. and Speg. Michelia **2**: 373. 1881 must be rejected, being founded on young examples of the present species in which the appendages were immature and without the uncinate apex. Ellis (116) and Massee (238) have pointed this out, and Saccardo himself has, in the Sylloge, **9**: 367. 1891 withdrawn the genus. [*Pleochaeta*, however, is still kept up in a subsequent paper by Saccardo (313) published in 1896 and in the

Syll. Fung. **14**: 16. 1899; Lindau also (in Engler and Prantl's Pflanzenfamilien, **1**[1]: 328, 331. 1897) retains the genus].

13. U. CONFUSA Massee

Uncinula polychaeta Berk. & Curt. Grevillea, **4**: 159. 1876.

Pleochaeta Curtisii Sacc. & Speg.; Sacc. Syll. Fung. **1**: 9 (partim). 1882.

Uncinula confusa Massee, Grevillea, **17**: 78. 1889; Sacc. Syll. Fung. **9**: 367. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 19. 1892.

"Peritheciis sparsis; appendicibus multis. On leaves of *Celtis occidentalis*, Car. No. 5619. Perithecia scattered; appendages about 28, 1 ½ longer than the diameter of the perithecia, hyaline." (Berk. Grevillea, **4**: 159. 1876).

"Hypophyllous; mycelium very scanty, not forming spots; perithecia scattered, usually not more than two or three on a leaf, 150–200 μ diam., appendages 25–28, simple, colorless, very slender, about 300 × 2–3 μ; apices strongly involute, not at all incrassated; asci about 25, cylindrico-clavate, tetrasporous; spores colorless, simple, elliptic-oblong, 20 × 10 μ" (Massee, Grevillea, **17**: 77. 1889).

Massee's description was based on the result of an examination of the type specimen of "*Uncinula polychaeta*" in the Kew Herbarium. Unfortunately, I have not been able to find on this type-specimen any perithecia which show the characters described by Berkeley and Massee, but, curiously enough, I have found several perithecia of *Uncinula parvula* on the leaf, agreeing perfectly with this species in possessing a diameter of 100–110 μ, 50–70 short, narrow appendages, 5–6 broadly-ovate asci, and 4–7 spores.

The question naturally presents itself, Could this have been the fungus examined by either Berkeley or Massee? I do not think this is possible. In Berkeley's description the rather contradictory characters, "appendicibus multis" and "appendages about 28" appear, but, what is very important, on the type sheet at Kew, Berkeley has given a drawing of a perithecium showing 28 appendages, slightly exceeding the diameter of the perithecium. In the diagnosis, moreover, the appendages are described as "1 ½ longer than the diameter of the perithecia." In Massee's description the additional characters given, "perithecia 150–200 μ diam.,

asci about 25, cylindrico-clavate" quite prohibit us from supposing that *U. parvula* was under observation.

We seem forced to the conclusion, therefore, that *U. confusa* is a distinct species, one that has apparently disappeared since its original discovery.

U. confusa and *U. polychaeta* were for some time greatly confused with one another. Both species were originally described on page 159 of Grevillea, **4**: 1876; the former appears first on the page as "*Erysiphe polychaeta* Berk. and Curt."; the latter as "*Uncinula polychaeta* Berk. and Curt." The essential characters given for each were these: *E. polychaeta*, appendages many, about equal to the diameter of the perithecium, straight, asci elongated, clavate; *U. polychaeta*, appendages about 28, 1½ longer than the diameter of the perithecium. As a matter of fact, the first species proved to be a true *Uncinula*, and the description "appendages straight" referred only to the immature condition.

"*Erysiphe polychaeta*" has occurred in several places in North America, whilst "*Uncinula polychaeta*" has not been refound since its original discovery. It was not unnatural, therefore, that many botanists meeting with an *Uncinula* on leaves of *Celtis* should refer it to the *Uncinula polychaeta* of Berk. and Curt., rather than to the *Erysiphe polychaeta* of these authors. This was done by Ravenel (Fung. Carol. Exsicc. fasc. **4**: 68) and by Ellis and Everhart in their Exsiccati (N. Amer. Fung. 2113). The same mistake was made by Ellis in the Journal of Mycology, **2**: 52, 53. 1886, where an attempt was made to reconcile the description of the few appendages of *U. polychaeta* Berk. and Curt. with the presence of numerous ones in the plant under observation by saying "The statement in Grevillea that the number of appendages is about 28 is evidently a typographical mistake for 228," and finally by Tracy and Galloway, who gave an excellent figure and description, and who similarly supposed that the description "about 28" was probably a misprint for 280.

Massee (238) first pointed out that "*Erysiphe polychaeta*" was an *Uncinula*, and that this was the species which the authors mentioned above had had under observation, and wrongly identified with the "*Uncinula polychaeta*" of Berk. and Curt. The specific name "*polychaeta*" having to be used, in accordance with

the rules of priority for the *Uncinula*, originally called "*Erysiphe polychaeta*," it became necessary to rename the *Uncinula polychaeta* of Berk. and Curt., which is now known as *Uncinula confusa* Massee.

14. U. AUSTRALIS Speg. [Fig. 61]

Uncinula australis Speg. Fung. Guaran. Pug. 1 : 66, n. 167. 1886; Sacc. Syll. Fung., addit. ad. vols. I.–IV : 1. 1886; and 9 : 366. 1891.

Epiphyllous; mycelium persistent, densely compacted and effused over the surface of the leaf, or thinner and in scattered patches; perithecia scattered, 120–138 μ in diameter, globose-depressed, cells small, about 8 μ wide; appendages numerous, 35–60, 1¼–1½ times the diameter of the perithecium, simple, colorless, aseptate, thin-walled throughout, rough and slightly enlarged in the upper half, but not swollen at the apex, which is simply uncinate; asci about 10, broadly ovate, shortly stalked, 58–65 × 32–38 μ; spores 8, rarely 7, 18–20 × 10–12 μ.

"Epiphylla; mycelium arachnoideum, grisecenti-album, late folia ambiens, eisque arcte adnatum, tenue, compactiusculum, non pulverulentum; perithecia densiuscule hinc inde sparsa, globoso-depressa, minuta (100–120 diam.) atra, glabra, membranaceo-coriacella, contextu parenchymatico, parum perspicuo, fuligineo, basi 20–40 appendicibus radiantibus ornata; appendices divaricatae (100–130 × 4–7), utrinque gradatim, attenuatae et laeves, medio saepius incrassatulae ac minutissime densiusculeque granuloso-papillosae, apice saepius semel plus minus ve circinatae (rarius rectae atque obtusata), hyalinae. Asci et sporae non visa." (Speg., *loc. cit.*)

Host.—*Eugenia* sp.

Distribution.—SOUTH AMERICA: Paraguay.

The first description given above is drawn up from the specimens in the Kew Herbarium, and in the Herbarium of the Paris Museum, labelled "B. Balansa, Pl. du Paraguay, 1878–1884. Nr. 3814. *Uncinula australis* Speg. Fung. Guaran. pug. 1 : 66. Feuilles d'*Eugenia*. Naranjo, sur la Cordillère de Péribébuy, 24 mai 1883." I have seen no other examples. The original specimens from which Spegazzini drew up his diagnosis, given above, were too young to contain asci, and the description of the appendages as sometimes "straight and obtuse" doubtless refers to the immature condition.

U. australis is apparently distinct from *U. salicis* in the 8-spored asci.

15. U. DELAVAYI Patouill. [Fig. 88]

U. Delavayi Patouill. Journ. de Bot. **2**: 217 (*cum icon.*). 1888; Sacc. Syll. Fung. **9**: 367. 1891.

Hypophyllous; mycelium evanescent; perithecia subgregarious, rounded-lenticular, 98–136 μ in diameter, cells large, 15–20 μ wide, appendages very few, 6–12, usually shorter than the diameter of the perithecium, rarely slightly exceeding it, simple, stout, 7–8 μ wide near the base, hyaline, thin-walled and enlarged at the apex, becoming thick-walled, refractive and sometimes rough towards the base, usually slightly curved throughout their length, colorless, aseptate; asci 4–11, broadly ovate or oblong, very shortly stalked, 58–68 × 34–38 μ; spores 6 or 7, rarely 5, 20–22 × 10–12 μ.

Host.—*Ailanthus* sp.

Distribution.—ASIA: China (Yunnan).

Of a distinct habit in the short, stout, usually curved appendages, not exceeding 12, and usually about 8 in number. *U. Delavayi* is most nearly allied to *U. Sengokui*, which differs in the more numerous, crowded appendages, not or scarcely enlarged upwards.

I am indebted to M. Patouillard for a specimen (now in the Kew Herbarium) from which the above description was drawn up.

M. Patouillard gives (274) a good figure of the present species.

16. U. AUSTRALIANA McAlpine. [Figs. 94, 95]

U. Australiana McAlpine, Journ. Linn. Soc. N. S. Wales, **24**: 302. *pl. 23. f. 5–9.* 1899.

Amphigenous; mycelium persistent or subpersistent; perithecia usually gregarious in patches on the mycelium, sometimes more or less scattered, 90–140 μ in diameter, usually about 115 μ, cells 10–15 μ wide; appendages 7–20, usually about 12, about equalling the diameter of the perithecium, rarely 1½ times the diameter, 1-septate and colored pale- or dark-brown at the base (sometimes one here and there aseptate and colorless), simple, smooth, thin-walled, narrowed upwards when young, not enlarged upward when mature, about 5 μ wide in the upper half, apex usually helicoid; asci 3–5, broadly ovate to subglobose, with or without a short stalk, 42–50 × 30–40 μ; spores 5–7, rarely 8, 20–22 × 10–12 μ.

Hosts.—Lagerstroemia Indica, L. ovalifolia.

Distribution.—ASIA: Japan (Sendai, K. Miyabe, Aug., 1893, and Tokyo, S. Hori., 1896).

AUSTRALIA: New South Wales Botanic Gardens, Sydney.

At the beginning of 1899 Professor Miyabe sent me among some Japanese Erysiphaceae an *Uncinula* on *Lagerstroemia Indica*, with the following note; "*U. lagerstroemiae* n. sp. Appendages very characteristic, their tips are circinate very tightly in a helicoid manner; 78–120 × 4.5 μ. Their number is few (3–7).

Subsequently I received from Professor McAlpine an *Uncinula* on *Lagerstroemia ovalifolia* ("sparingly on leaves, but covering entire inflorescence") from the Botanic Gardens, Sydney, under the name of *U. Australiana* McAlp.; with a note that this name would shortly be published.

A comparison of the Japanese and Australian plants showed them to be identical.

U. Australiana is somewhat intermediate between *U. necator* and *U. Sengokui*. The latter species differs in the colorless, more numerous, crowded appendages, distinctly stouter throughout, and 8–9 μ wide in the upper half (where those of *U. Australiana* are only about 6 μ wide); *U. necator* (to the few, short-appendaged forms of which the present species closely approaches) differs in the always more colored appendages. In *U. Australiana* the color is strictly limited to the base, not occurring above the septum; in all forms of *U. necator* the color extends upwards for a considerable distance. In the present species, also, it is not at all uncommon to find some of the appendages of a perithecium quite colorless.*

17. **U. fraxini** Miyabe mss. sp. nov. [Figs. 69–72]

Amphigenous; mycelium evanescent; perithecia scattered, small, 75–105 μ in diameter, usually 80–90 μ, globose-depressed, cells distinct, irregular in shape, averaging 10 μ wide; appendages 10–28, 1½ to 2½ times the diameter of the perithecium, straight or slightly curved, simple, aseptate, thin-walled and hyaline throughout, apex simply uncinate or sometimes distinctly helicoid; asci 4–7, usually 5 or 6, oblong to subglobose, occasionally shortly stalked, 45–58 × 30–40 μ; spores 8, 16–18 × 9–10 μ.

Since the above remarks were written, McAlpine (225) has published an account of his species. It is here stated that the appendages are sometimes forked.

Host.—Fraxinus longicuspis.

Distribution.—ASIA: Japan (Sapporo, K. Miyabe, Sept., 1893).

Among the collection of Japanese Erysiphaceae Professor Miyabe sent me specimens of the above plant under the mss. name of *U. fraxini.* As it appears to be a distinct species hitherto undescribed, I have drawn up the above description from the material sent. Professor Miyabe sent the following notes with the specimens: "*U. fraxini* n. sp. Perithecia 82–98 μ; appendages 11–20, 170–225 μ long, slender; asci (6) 30 × 45–49 μ, 8-spored; spores 14–15 × 7–8 μ."

U. fraxini may be known by the evanescent mycelium, hyaline and thin-walled appendages, and the 8-spored asci.

18. **U. Sengokui** sp. nov. [Figs. 64–68]

Amphigenous; mycelium evanescent, or subpersistent, very thin and effused over the upper surface of the leaf; perithecia subgregarious or scattered, 98–135 μ in diameter, cells 10–15 μ wide; appendages more or less crowded, 20–36, equally or (usually) slightly exceeding the diameter of the perithecium, simple, colorless, aseptate, or occasionally 1-septate, stout, 7–8 μ wide in the lower half, not or scarcely enlarged upwards, often curved throughout their length, hyaline above, becoming refractive and thick-walled at the base; asci 7–12, ovate to broadly ovate, usually shortly stalked, 48–58 × 30–34 μ, spores 5–6, 18–20 × 10 μ.

Host.—Celastrus articulatus.

Distribution.—ASIA: Japan (Komaba, Tokyo, October, 1895, K. Sengoku).

Among the collection of Erysiphaceae sent to me from Japan by Professor Miyabe, the above species of *Uncinula* appears to be new. Its affinity is undoubtedly with *U. Delavayi*, but the more numerous crowded appendages not or scarcely enlarged upwards easily distinguish the present species.

U. Sengokui, except for the absence of color in the appendages, much resembles certain Japanese forms of *U. necator.*

From all forms of *U. Clintonii*, the present species may be distinguished by the wider base of the appendages.

MICROSPHAERA Lév. Ann. sci. nat. III. 15: 154, sub *Calocladia*, & 381. 1851

Perithecia globose to globose-depressed: asci several, 2–8-spored. Appendages not interwoven with the mycelium, branched in a definite manner at the apex, which is usually several times dichotomously divided, and often very ornate, rarely (*M. astragali*) undivided or once dichotomous. Etym. *μικρος*, *parvus*, and *σφαιρα*, *sphaera*.

Distribution.—Europe, Asia, and North America; 13 species and 6 varieties.

As a rule, the genus *Microsphaera* is easily known by the much-divided and ornate apex of the appendages. In one species, however, *M. astragali*, the appendages are very frequently unbranched at the apex, and through this species *Microsphaera* approaches the genus *Erysiphe*. From all species of *Erysiphe*, however, *M. astragali* is distinct in the long, white, assurgent, fasciculate appendages. In *E. tortilis*, where the habit is somewhat similar, the appendages are brown. At first sight it seems unnatural to separate in different genera these two species, and some authors have preferred to place *M. astragali* in the genus *Erysiphe*. Apart from the fact, however, that the apex of the appendages in *M. astragali* is sometimes definitely branched in a dichotomous manner (so making the view possible that the unbranched condition is to be considered merely as the result of immaturity), this species is evidently too closely allied to *M. Bäumleri* to be separated generically from it; while *E. tortilis* is similarly very close to certain forms of *E. polygoni*. Magnus (231, p. 150) has lately proposed that the characters of the two genera *Microsphaera* and *Erysiphe* should be emended, but the definitions proposed by this author (which involve the transference of *E. tortilis* to the genus *Microsphaera*) seem to me to be less natural than that which gives the strictly apical branching of *Microsphaera* as the difference of chief generic importance. Magnus (*l. c.*) speaks of angularly bent appendages as being distinctive of the genus *Erysiphe*; this character, as separating the two genera, would, however, break down in *M. euphorbiae* and in many forms of *E. communis*.

I have not seen sufficiently mature examples of *M. umbilici* on *Cotyledon* (*Umbilicus*) *Semenovii* and *M. ferruginea* on *Verbena*

hybrida to be able to indicate the essential specific characters (probably to be found in the shape of the mature apex of the appendages). These two species, therefore, are not included in the key; descriptions, however, of the specimens will be found at the close of the account of the genus.

Key to the Species of Microsphaera*

1. Asci 2-spored, appendages densely crowded, flaccid, about equalling the diameter of the perithecium. 6. *Mougeotii.*
   Asci more than 2-spored. 2.

2. Appendages 2½–7 times the diameter of the perithecium, usually much contorted and angularly bent, apical branching very irregular and lax, with the branches very flexuous and more or less curled. 9. *euphorbiae.*
   Appendages long or short without the above characters. 3.

3. Tips of some or all of the ultimate branches of the appendages recurved. 4.
   Tips not recurved. 11.

4. Appendages 8–12 times the diameter of the perithecium. 10 *Guarinonii.*
   Appendages less than 8 times the diameter of the perithecium. 5.

5. Appendages long and flaccid. 6.
   Appendages short, not exceeding 2½ times the diameter of the perithecium, not flaccid. 8.

6. Apex of appendages much branched, branching ornate, more or less close, spores 22–26 × 12–15 μ. 4. *alni*, var. *extensa.*
   Apex less branched, more or less widely forked, or branching close and simple, spores 18–23 × 9–13 μ. 7.

7. Appendages usually 3½, not exceeding 5½ times the diameter of the perithecium, asci 3–7, ovate-globose, 38–48 μ long. 4. *alni*, var. *divaricata.*
   Appendages 2½–8 times the diameter of the perithecium, asci 2–16, ovate-oblong, 45–72 μ long. 4. *alni*, var. *vaccinii.*

8. Appendages more or less contorted, apical branching very lax and irregular. 4. *alni*, var. *ludens.*
   Appendages not contorted, apical branching closer and regular. 9.

9. Tips of the ultimate branches of the appendages not all regularly and distinctly recurved. 4. *alni*, var. *lonicerae.*
   Tips all regularly and distinctly recurved. 10.

10. Axis of some of the appendages not dividing dichotomously at the apex, but bearing sets of opposite branches (Fig. 16). 4. *alni*, var. *calocladophora.*
    Appendages regularly dichotomous at apex. 4. *alni.*

11. Appendages 3–7 times the diameter of the perithecium, colored nearly to apex. 8. *Russellii.*
    Appendages colorless. 12.

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* *M. umbilici* and *M. ferruginea* are not included in this key (see above).

12. Appendages long and penicillate. 13.
Appendages not penicillate. 15.

13. Apex of appendages often undivided, or irregularly 1–2 times dichotomous. 3. *astragali.*
Apex more divided. 14.

14. Appendages 4–6 times the diameter of the perithecium, branching diffuse and irregular. 13. *Bäumleri.*
Appendages 2½–5½ times the diameter of the perithecium, apex more divided, branching closer. 2. *euonymi.*

15. Branching of the appendages lax, irregular. 16.
Branching closer and regular. 17.

16. Appendages 2–4 times the diameter of the perithecium, not contorted, ultimate branches long, forming a narrow fork. 7. *diffusa.*
Appendages 1–2 times the diameter of the perithecium, more or less contorted, branching more irregular, with short ultimate branches. 4. *alni*, var. *ludens.*

17. Apex of appendages with very short primary and secondary branches more or less digitate (Fig. 34). 5. *grossulariae.*
Apex primary and secondary branches longer. 18.

18. Apex with short, widely spreading, usually curved ultimate branches. 4. *alni*, var. *lonicerae.*
Apex with long, straight ultimate branches, not widely spreading. 1. *berberidis.*

1. M. BERBERIDIS (DC.) Lév. [Figs. 40, 41]

Erysiphe berberidis DC. Fl. Fr. **2**: 275. 1805; Tul. Sel. Fung. Carp. **1**: 204. *pl. 5. f. 1.* 1861; de Bary, Beitr. Morph. Phys. Pilz. **1**: § xiii. 51. 1870.

Alphitomorpha penicillata, var. *berberidis* Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 40. 1819; Wallr. Fl. Crypt. Germ. **2**: 754. 1833.

Erysibe berberidis DC.; Gray, Nat. Arr. Brit. Pl. **1**: 590. 1821.

E. divaricata β Schlecht. Fl. Berol. **2**: 169. 1824.

E. penicillata, var. *berberidis* Lk.; Willd. Sp. Pl. **6**: 114. 1824; Rabenh. Deutschl. Krypt. Fl. **1**: 236. 1844.

Erysiphe penicillata, var. *berberidis* Fr. Syst. Myc. **3**: 244. 1829; Duby, Bot. Gall. **2**: 871. 1830.

E. penicillata Lk.; Johnst. Fl. Berw. **2**: 143. 1831; Berk.; Sm. Engl. Fl. **5**: 327 (partim). 1836.

Erysibe divaricata Rabenh. Fl. Lusat. **2**: 420 (partim). 1840.

Microsphaera berberidis Lév. Ann. sci. nat. III. **15**: 159. *pl. 10. f. 28* (sub *Calocladia*). 1851; Cooke, Micr. Fung. 219. *pl.*

11. f. 229–232. 1865; Cooke, Handb. Brit. Fung. **2**: 649. 1871; Sacc. Syll. Fung. **1**: 13. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 36. 1884; Karst. Act. Soc. Faun. Flor. Fenn. **2**: 91. 1885; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 243. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 746. 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 92. 1897.

Calocladia berberidis Lév. Dietr. Blick. Crypt. Ostseeprov. 336. 1856; Karst. Myc. Fenn. **2**: 196. 1873.

Podosphaera berberidis Lév.; Quél. Champ. Jur. Vosg. **3**: 106. 1875.

EXSICC.: Rab.-Wint.-Patzsch. Fung. Eur. 3855; Rab. Fung. Eur. 555, 2318; Rehm. Ascom. 499; Fckl. Fung. Rhen. 693; de Thüm. Fung. austr. 137; Syd. Myc. March. 246; Roumeg. Fung. Select. Gall. Exsicc. 159; Oudem. Fung. Neerl. Exsicc. 153; Rab. Herb. Myc. ed. 2, 459; Cooke, Fung. Brit. Exsicc. 95, ed. sec. 283; de Thüm. Myc. univ. 1838; Kunze. Fung. select. exsicc. 320; Westend. Herb. Crypt. Belg. 738; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 519; Vize. Fung. Brit. 93; *Erikss. Fung. par. scand. 143.

Amphigenous; mycelium evanescent, or sometimes sub-persistent in irregular patches, or very thinly effused over the whole surface of the leaf; perithecia usually scattered, occasionally more or less densely gregarious, 90–125 μ in diameter, cells 10–15 μ wide; appendages 5–20, 1¼–2½ times the diameter of the perithecium, colorless, thin-walled above, becoming thick-walled in the lower half when mature, aseptate, smooth, apex regularly 4 times dichotomously branched, branching rather close, branches of the last order more or less parallel, never widely spreading, tips of ultimate branches not recurved; asci 4–9, ovate-oblong, very shortly stalked, 48–56 × 26–32 μ; spores 3–6, usually 4, 18–22 × 9–11 μ.

Host.—B. aquifolium, B. vulgaris.

Distribution.—EUROPE: Britain, France, Belgium, Netherlands, Germany, Switzerland, Italy (307), Austria-Hungary, Servia (318), Norway, Sweden, Finland (192), Russia.

ASIA:—Cyprus, Transcaucasia (338), Turkestan, Japan.

Somewhat intermediate between *M. grossulariae* and *M. alni*, var. *lonicerae*. The apex of the appendages is regularly 4 times divided, and the straight ultimate branches do not spread widely, but lie more or less parallel to one another, in this respect some-

what recalling those of *M. grossulariae*. In *M. berberidis*, however, the branches of the first and second orders are of about equal length to the others, so that the manner of branching of the whole apex differs conspicuously from that of *M. grossulariae*, where the primary and secondary branches are extremely short (*cf.* Figs. 34, 35, and 40, 41). *M. grossulariae* has, also, shorter appendages and slightly larger spores.

M. alni, var. *lonicerae* differs from *M. berberidis* in the spreading ultimate branches of the apex of the appendages, which occasionally have recurved tips, the usually fewer asci, etc.

At the beginning of last November my attention was directed to some bushes of *Berberis* (*Mahonia*) *aquifolium* in a shrubbery near Reigate, Surrey, England, which were, chiefly on the young shoots, more or less white with the mycelium of *M. berberidis*. The perithecia were densely gregarious on both sides of the leaf, and agreed in all characters with examples of the species on the usual host, *B. vulgaris*. This occurrence on an evergreen species of *Berberis* is very interesting, as hitherto in its wide range in Europe, and in Asia, the species has been supposed to be absolutely confined to a single species or host-plant, viz. *Berberis vulgaris*.

The Japanese example of the present species was sent to me by Prof. Miyabe, and agrees perfectly with the European plant, and the same is the case with beautiful specimens sent by Prof. Gennardius from Cyprus.

2. M. EUONYMI (DC.) Sacc.

Erysiphe euonymi DC. Fl. Fr. **6**: 105. 1815; Duby, Bot. Gall. **2**: 871. 1830.

Alphitomorpha comata Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 40. 1819; Wallr. Fl. Crypt. Germ. **2**: 757. 1833.

A. euonymi Wallr. Ann. Well. Ges. **4**: 245. 1819.

Erysibe comata (Wallr.) Ficin. Schub. Fl. Gegend. Dresd. **2**: xix. 1823; Lk. in Willd. Sp. Pl. **6**: 114. 1824; Rabenh. Deutschl. Krypt. Fl. **1**: 231. 1844.

Erysiphe penicillata, var. *euonymi* Fr. Syst. Myc. **3**: 244. 1829.

E. comata Lk.; Secret. Mycogr. Suisse, **3**: 653. 1833.

Microsphaera comata Lév. Ann. Sci. Nat. III. **15**: 157. *pl. 9.*

f. 23 (sub *Calocladia*). 1851; Cooke, Handb. Brit. Fung. **2**: 649. 1871.

Calocladia comata Lév.; Dietr. Blick. Crypt. Ostseeprov. 336. 1856.

Podosphaera comata (Lév.) Quél. Cham. Jur. Vosg. **3**: 106. 1875.

Microsphaera euonymi (DC.) Sacc. Syll. Fung. **1**: 11. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1²**: 37. 1884; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 242. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 749. 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 90. 1897.

Exsicc.: de Thuem. Fung. austr. 1238; Sacc. Myc. Ven. 892; Syd. Myc. March. 199, *4335, *4336; Fckl. Fung. Rhen. 692; Cooke, Fung. Brit. Exsicc. 94; Rab. Fung. Eur. 438, 1324, 2319; Rehm. Ascom. 248; Roumeg. Fung. Gall. exsicc. 3224; Vize. Fung. Brit. 196; *de Thuem. Myc. univ. 847; *Kneiff. & Hart. Pl. Crypt. Bad. 55; Wint. Fung. Helvet. Supp. 84 (in Herb. Earle).

Usually hypophyllous, very rarely amphigenous; mycelium evanescent or nearly so; perithecia more or less densely gregarious, 85–138 μ in diameter, cells obscure, about 10 μ wide; appendages 6–14, 2½–5½ times the diameter of the perithecium, flaccid, colorless, thin-walled above, becoming thick-walled towards the base, aseptate, smooth, fasciculate and forming a flaccid "pencil" which lies on the surface of the leaf, apex variously 3–5 times dichotomously, or sub-dichotomously, branched, branching variable, lax or close, tips of ultimate branches usually straight; asci 3–7, ovate to broadly ovate, 50–60 × 30–38 μ, with a short stalk; spores 3–5, 20–23 × 10–12 μ.

Hosts.—*Euonymus Europaeus*, *E. verrucosus* (294).

Distribution.—EUROPE: Britain, France, Belgium (47) (209), Netherlands (263), Germany, Switzerland, Italy, Austria-Hungary, Denmark, Finland, Russia.

A well-characterized species in the fasciculate habit of the long appendages (which form when mature a flaccid "pencil"), and the much-branched apex.

In other characters *M. euonymi* is very variable, especially as regards the manner of branching of the apex of the appendages. The branching is sometimes somewhat lax, and the apex is 3 times dichotomously divided, with the primary and secondary branches more or less recurved, often strongly so, and even the

tips of the ultimate branches show, in this form, a slight tendency to become recurved; the specimen in de Thüm. Fung. austr. 1238 illustrates this form. More frequently, however, the apex is closely 4–5 times branched, when the dichotomous arrangement often ceases at the branches of the third order, and the subsequent branches are irregularly arranged, short, often very flexuous and lying in different planes, with the tips not at all recurved, *e. g.*, the specimen in Rabenh. Fung. Eur. 1324. In other specimens, again, the branching is dense, the primary branches short, and the subsequent ones long, straight and narrow.

M. euonymi is confined to Europe; the record of its occurrence in California "on *Euonymus*" by Harkness and Moore (159) is doubtless an error.

3. M. ASTRAGALI (DC.) Trev. [Figs. 47–51]

Erysiphe astragali DC. Fl. Fr. **6**: 105. 1815; Duby, Bot. Gall. **2**: 871. 1830; Tul. Sel. Fung. Carp **1**: 206. *pl. 2. f. 4.* 1861; de Bary, Beitr. Morph. Phys. Pilz. **1**: § xiii. 51. 1870.

Alphitomorpha holosericea Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 41. 1819.

A. astragali Wallr. Ann. Wett. Ges. **4**: 244. 1819.

Erysibe holosericea (*astragali*) Lk.; Willd. Sp. Pl. **6**: 115. 1824; Rabenh. Deutschl. Krypt. Fl. **1**: 231. 1844.

Erysiphe communis, & *E. holosericea* Fr. Syst. Myc. **3**: 240. 1829.

Alphitomorpha sericea Wallr. Fl. Crypt. Germ. **2**: 757. 1833.

Microsphaera holosericea Lév. Ann. Sci. Nat. III. **15**: 159. *pl. 9. f. 27* (sub *Calocladia*). 1851.

M. astragali (DC.) Trev., Spighe e Paglie, **1**: 39. 1853 (fide Sacc.); Sacc. Syll. Fung. **1**: 12. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 35. 1884; Jacz. Bull. l'Herb. Boiss. **4**: 746. 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 91. 1897.

Calocladia holosericea Lév. Dietr. Blick. Crypt. Ostseeprov. 336. 1856; Fckl. Symb. Myc. 82. 1869–70.

Erysibe astragali Schroet.; Cohn's Krypt. Fl. Schles. **3**: 241. 1893.

EXSICC.: Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 924,*ed. 2, ser. 1, 224; Rab. Fung. Eur. 439, 2413; Westend. Herb. Crypt. Belg. 1059;

Roumeg. Fung. Gall. Exsicc. 1164, 3141 ; de Thüm. Fung. austr. 459; Fckl. Fung. Rhen. 694; Sacc. Myc. Ven. 148; Rab. Herb. myc. ed. 2, 469; Oudem. Fung. Neerl. Exsicc. 159; Erb. Critt. Ital. 144, *193 ; Rehm. Ascom. 448; * Syd. Myc. March. 979; * Romell. Fung. exsicc. praes. scand. 62.

Hypophyllous, or amphigenous ; mycelium evanescent, or sometimes faintly persistent; perithecia usually densely gregarious, but sometimes scattered, globose-depressed, 95–146 μ in diameter, cells small, about 10 μ wide, appendages 5–18, 4–10 times the diameter of the perithecium, smooth, colorless and aseptate (sometimes brown towards the base, and then usually septate), hyaline above, becoming thick-walled and refractive in the lower half when mature, flexuous, sub-flaccid, penicillate, apex frequently unbranched (? immature) or once or twice dichotomously branched, branching lax and vague, primary branches usually long, and more or less recurved, tips of ultimate branches not recurved; asci 5–12, ovate-oblong to broadly-ovate, 52–68 × 30–38 μ, usually stalked; spores 3–6, usually 4, 20–23 × 10–12 μ.

Hosts.—*Astragalus Cicer* (164*) (384), *A. Glycyphyllos*, *A. onobrychis* (390).

Distribution.—EUROPE : Britain, France, Belgium, Netherlands, Germany, Switzerland, Italy, Austria-Hungary, Denmark, Norway, Sweden, Russia.

M. astragali is related *M. Bäumleri* and *M. euonymi* in the flaccid penicillate appendages, but differs from both species in the apex of the appendages being less branched. In the present species the very long and flexuous appendages, which are about 6 μ wide, are thick-walled and shining in their lower half, and whether seen singly under the microscope or in dense clusters on the leaf, present a shining silky appearance which makes the old specific name of *holosericea* very appropriate. The apical branching of the appendages is extremely ill-defined, in fact, there are usually only two or three appendages in any perithecium which show any signs of branching at all. I have once seen the apex feebly 3-times dichotomous, rarely it is twice dichotomous, but is usually (when branched at all) only once forked, as is generally described.

Several authors, on account of this slight branching of the appendages, have placed the present species in *Erysiphe;* the apical branching, however, when present, is regularly dichotomous and

definite, and unlike that found in *Erysiphe*, and the proper position of the present plant is certainly in *Microsphaera*, to one species of which—*M. Bäumleri*—it shows a close relationship.

M. astragali is confined to Europe ; the plants referred to this species from North America all belong (as far as I have seen) to *M. euphorbiae*. This is the case with the specimen "*M. holosericea* Lév., on leaves of *Astragalus Cooperi*, Buffalo, N. Y. (C. H. Peck, n. 198)," recorded by Cooke and Peck in the Journal of Botany (91), and mentioned in Saccardo's Sylloge, **1** : 12; also with the specimen named "*M. holosericca*" on an unnamed host-plant (probably *Astragalus Drummondii*), n. 1572, Flora of Colorado, Colorado Springs (5500 ft.), 1879 (M. E. Jones); and with other examples.

Massalongo (237, p. 127) has recorded "*M. astragali* β *cytisi*" on "*Cytisus alpinus* (vel *C. Laburnum*)." Specimens (now in the Kew Herbarium) kindly sent to me by this author prove to belong to *M. Guarinonii*.

Winter records *M. astragali* on *Astragalus virgatus*, but the fungus so-named on this host in the Exsiccati quoted by this author (de Thuem. Fung. austr. 1237) is *Erysiphe polygoni*.

4. M. ALNI (Wallr.). [Figs. 1–14]

Alphitomorpha penicillata, var. *alni* Wallr. Berl. Ges. Nat. Freund. Verh. **1** : 40 (syn. excl.). 1819.

A. alni Wallr. Ann. Wett. Ges. **4** : 237 (syn. excl.). 1819.

A. penicillata, var. *rhamni cathartici* Schlecht. Berl. Ges. Nat. Freund. Verh. **1** : 49. 1819.

Erysibe penicillata Lk. ; Willd. Sp. Pl. **6** : 113 (excl. vars. *grossulariae* and *berberidis*, and syn. *E. alni* DC.). 1824 ; Rabenh. Deutschl. Krypt. Fl. **1** : 236 (partim). 1844.

Erysiphe penicillata Fr. Syst. Myc. **3** : 244 (partim). 1829; Duby, Bot. Gall. **2** : 871 (partim). 1830; Berk.; Sm. Engl. Fl. **5** : 327 (partim). 1836.

E. viburni Duby, Bot. Gall. **2** : 872. 1830.

Alphitomorpha penicillata Wallr. Fl. Crypt. Germ. **2** : 754 (partim). 1833.

Erysiphe densissima Schwein. Syn. Fung. Am. Bor. 269. 1834.

E. ceanothi Schwein. Syn. Fung. Am. Bor. 269. 1834; Sacc. Syll. Fung. **1**: 22. 1882.

E. viburni Schwein. Syn. Fung. Am. Bor. 269. 1834; Sacc. Syll. Fung. **1**: 21. 1882.

E. syringae Schwein. Syn. Fung. Am. Bor. 270. 1834; Sacc. Syll. Fung. **1**: 21. 1882.

E. quercinum Schwein. Syn. Fung. Am. Bor. 270. 1834; Sacc. Syll. Fung. **1**: 22. 1882.

Microsphaera Hedwigii Lév. Ann. sci. nat. III. **15**: 155. *pl. 8. f. 19* (sub *Calocladia*). 1851; Cooke, Micr. Fung. 219. 1865; Cooke, Handb. Brit. Fung. **2**: 648. *f. 316.* 1871; Sacc. Syll. Fung. **1**: 11. 1882; Oudem. Rév. Champ. Pays.-Bas. **2**: 90. 1897.

M. penicillata Lév. Ann. sci. nat. III. **15**: 153. *pl. 8. f. 21* (sub *Calocladia*) (excl. syn. *E. alni* DC. & *Sclerot. Erysiphe*, var. *alnea* Schleich). 1851; Cooke, Micr. Fung. 219. *pl. 11. f. 234.* 1865; Cooke, Handb. Brit. Fung. **2**: 649. 1871; Sacc. Syll. Fung. **1**: 13. 1882; Oudem. Rév. Champ. Pays.-Bas. **2**: 92 (excl. syn. *E. alni* DC.). 1897.

M. Friesii Lév. Ann. sci. nat. III. **15**: 156. *pl. 8. f. 20* (sub *Calocladia*) (excl. syn.). 1851; Sacc. Syll. Fung. **1**: 13. 1882.

Calocladia Friesii Lév. Dietr. Blick. Crypt. Ostseeprov. 337. 1856.

Erysiphe alni Tul. Sel. Fung. Carp. **1**: 203. *pl. 2. f. 5–7* (excl. syn. *E. alni* DC.). 1861.

Calocladia Hedwigii Lév. Fckl. Symb. Myc. 81. 1869–70.

C. penicillata Lév.; Fckl. Symb. Myc. 81. 1869–70; Karst. Myc. Fenn. **2**: 196. 1873.

Microsphaera pulchra Cooke & Peck, Journ. of Bot. II. **1**: 12. 1872; Peck, Reg. Rep. **25**: 95. 1873; Sacc. Syll. Fung. **1**: 12. 1882.

M. Friesii, var. *syringae* Cooke & Peck, Journ. of Bot. II. **1**: 12. 1872.

M. Friesii, var. *vaccinii* Cooke & Peck, Journ. of Bot. II. **1**: 12. 1872.

M. semitosta Berk. & Curt. ex Cooke & Peck, Journ. of Bot. II. **1**: 13. 1872; Berk. & Curt. Grevillea, **4**: 160. 1876; Sacc. Syll. Fung. **1**: 11. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat.

Hist. **2**: 415. 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 69. *pl. 1. f. 12–14.* 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 25. 1892.

M. sparsa E. C. Howe; Cooke & Peck, Journ. of Bot. II. **1**: 171. 1872.

M. penicillata, var. *alni* Cooke & Peck, Journ. of Bot. II. **1**: 171. 1872.

M. densissima (Schwein.) Cooke & Peck, Journ. of Bot. II. **1**: 171. 1872; Peck, Reg. Rep. **26**: 80. 1874; Sacc. Syll. Fung. **1**: 15. 1882.

M. menispermi E. C. Howe, Bull. Torr. Club, **5**: 3. 1874; Sacc. Syll. Fung. **9**: 369. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 22. 1892.

M. platani E. C. Howe, Bull. Torr. Club, **5**: 4. 1874; Sacc. Syll. Fung. **9**: 369. 1891.

M. viburni E. C. Howe, Bull. Torr. Club, **5**: 43. 1874; Sacc. Syll. Fung. **9**: 369. 1891.

Podosphaera Hedwigii (Lév.) Quél. Champ. Jur. Vosg. **3**: 106. 1875.

P. penicillata (Lév.) Quél. Champ. Jur. Vosg. **3**: 106. 1875.

Microsphaera abbreviata Peck, Reg. Rep. **28**: 64. *pl. 2. f. 4, 5.* 1876; Sacc. Syll. Fung. **1**: 11. 1882.

M. Ravenelii Berk. Grevillea, **4**: 160. 1876; Sacc. Syll. Fung. **1**: 14. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 420. *f. 8.* 1887; Burr.; Ell. & Everh. N. Amer. Pyren. 23. 1892.

M. erineophila Peck, Bull. Torr. Club, **10**: 75. 1883; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 419. 1887; Sacc. Syll. Fung. Addit. ad Vols. I.–IV.: 2. 1886; and **9**: 368. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 29. 1892.

M. alni (DC.) Wint.; Rabenh. Krypt. Fl. Deutschl. **1**[2]: 38. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 92 (excl. syn. *E. alni* DC.). 1885; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 421 (excl. syn. *E. alni* and *M. Van Bruntiana* E. C. Howe). 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 71. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 27 (excl. syn. *E. alni* DC. and *E. betulae* DC.). 1892; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 244. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 748 (excl. syn. *E. alni*). 1896.

M. nemopanthis Peck, Reg. Rep. **38**: 102. 1886; Sacc. Syll. Fung. Addit. ad Vols. I.–IV.: 2. 1886; and **9**: 368. 1891.

M. quercina (Schwein.) Burr.; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 424 (partim). 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 72. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 28 (partim). 1892.

M. quercina, var. *abbreviata* Atkins. Journ. Elisha Mitch. Sci. **7**: 73. 1891.

Exsicc.: Syd. Myc. March. *247, 657, 2662, *3672, *3720, *3721, *3947, *4334, *4433; Fckl. Fung. Rhen. 690, 691, 695; Lib. Pl. Crypt. Ard. fasc. 1, 81; Rab. Fung. Eur. 437, 2031, *2032; Sacc. Myc. Ven. 147, 618, 619, 893; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 921, 922 (A. & B.), 923, *ed. 2, ser. 1, 221, 222, 223; de Thüm. Fung. austr. 138, 139; Baxt. Stirp. Crypt. Oxon.; Rehm. Ascom. 299, 446, 599, 848; Bri. & Cav. Fung. par. 40; Cooke Fung. Brit. exsicc. 218; de Thuem. Myc. univ. 56, 155, 557, 558, 958, 2054, 2055; Westend. Herb. Crypt. Belg. 112; and 831 (in Herb. Jard. bot. Bruxelles); Kunze. Fung. select. exsicc. 237, 318, 576; Rab. Herb. Myc. ed. 2, 474; and 462 sub *Erysibe guttata*, var. *betulae;* Ell. N. Amer. Fung. 428, 432, 659, 767, 770, 1325; Ell. & Everh. N. Amer. Fung. 660, 1539, 1945; and 559 sub *M. Dubyi;* sec. ser. 1783, 3008; Rab.-Wint.-Pazsch. Fung. Eur. 3953; Rav. Fung. Amer. Exsicc. 87, 626, 627; Rav. Fung. Car. Exsicc. 67, 68; Vize. Fung. Brit. 198, 473; Roumeg. Fung. Gall. Exsicc. 3650; Rab.-Wint. Fung. Eur. 3044, 3245, 3744; Roumeg. Fung. select. exsicc. 4563; *Ell. & Everh. Fung. Columb. 111, 508; *Wartm. & Wint. Schweiz. Crypt. 825; *Wartm. & Schenk, Schweiz. Krypt. 424; *Seym. & Earle, Econ. Fung. 45, 124, 176, 183, 187; Wint. Fung. Helvet. Supp. 85 (in Herb. Earle); Klotzsch. Herb. Myc. 178 (in Herb. Upsala Mus.); Schleich. cent. exsicc. 68 (in Herb. De Candolle).

Amphigenous; mycelium evanescent, or persistent, and then thin and usually more or less effused over the surface of the leaf, or rarely (as sometimes on *Quercus*, *Alnus*, *Viburnum* and *Vaccinium*) forming definite, more or less rounded patches; perithecia scattered or more or less densely gregarious, globose depressed, very variable in size, usually small, 66–110 μ in diameter,

sometimes 110–135 μ, cells 10–15 μ wide, rarely 15–18 μ; appendages very variable in number and length, 4–26, ⅓–2½ times the diameter of the perithecium, usually about 1½ times diameter, more or less rigid, colorless throughout or amber-brown at base, or rarely colored to the commencement of the apical branching, smooth, or occasionally rough toward the base, which usually becomes thick-walled, aseptate or occasionally 1–2-septate toward the base, apex variously but always more or less closely, 3–6 times dichotomously branched, tips of ultimate branches regularly and distinctly recurved; asci 3–8, ovate to ovate globose, 42–70 × 32–50 μ, usually but not always shortly stalked; spores 4–8, 18–23 × 10–12 μ.

Hosts.—Alnus glutinosa, A. incana and var. *virescens, A. maritima, A. rubra, A. serrulata, A. viridis, Apios tuberosa, Astragalus adsurgens* (60), *Betula alba, B. lenta, B. lutea, B. pumila* (60) (97), *Carpinus Americana* (60), *Carya alba, C. sulcata, Castanea dentata* (249), *C. sativa* and vars. *Americana* and *Japonica, Ceanothus Americanus, Celastrus scandens* (60), *Cephalanthus occidentalis, Cornus alternifolia, C. Amonum* (60), *C. macrophylla, C. stolonifera* (363), *Corylus Americana, C. rostrata* and var. *Mandshurica, Euonymus atropurpureus, Fagus atropunicea* (249), *F. ferruginea, Forestiera acuminata, Gleditschia triacanthos, Gymnocladus* sp., *Ilex decidua, I. mollis* (371), *I. verticillata* (97), *Juglans cinerea, J. nigra, Lathyrus ochroleucus, L. palustris* (61), *L. pratensis, L. venosus, Ligustrum medium, Lonicera flava, L. glauca, L. glaucescens, L. hirsuta* (60), *L. involucrata, L. oblongifolia, L. parviflora, L. sempervirens, L. Sullivantii* (60), *Lyonia paniculata* (60), *Menispermum Canadense, Nemopanthus fascicularis, Ostrya Virginica, Picrasma quassioides, Platanus occidentalis, Quercus alba, Q. aquatica, Q. bicolor, Q. bicolor* × *macrocarpa, Q. bicolor* × *Michauxii, Q. Catesbaei, Q. coccinea* and var. *tinctoria, Q. crispula, Q. dentata, Q. falcata, Q. imbricaria, Q. lyrata, Q. macrocarpa, Q. nigra, Q. obtusiloba, Q. Phellos, Q. Prinus, Q. Robur, Q. rubra, Rhamnus cathartica, Rhododendron nudiflorum, Sambucus Canadensis* (122), (265), *Schizandra Chinensis, Syringa Amurensis,* var. *Japonica, S. Persica* (269), *S. vulgaris, Tecoma radicans, Ulmus Americana, Vaccinium corymbosum, Viburnum acerifolium, V. dentatum, V. Lantana, V. Lentago, V. Opulus, V. prunifolium, V. pubescens, V. Tinus* (246), *Vicia Americana* and var. *linearis, Zelkova acuminata* [*Populus grandidentata*].

Distribution.—EUROPE: Britain, France, Belgium, Netherlands, Germany, Switzerland, Italy, Austria-Hungary, Denmark, Norway, Sweden, Russia.

ASIA: Transcaucasia (338), Japan.

NORTH AMERICA: United States—Maine, Vermont (153), Massachusetts, Connecticut, New York, Pennsylvania, Maryland, New Jersey, Delaware, West Virginia, North and South Carolina, Ohio, Michigan, Indiana, Alabama, Illinois, Mississippi, Wisconsin, Missouri, Iowa, Minnesota, South Dakota, Kansas, Montana, Wyoming, Colorado, California (159), Washington. Canada, New Brunswick, Ontario, Manitoba.

The most variable species of the Erysiphaceae. Starting with the forms described as *M. Hedwigii*, *M. Friesii* and *M. penicillata* by Léveillé, examination of authentic specimens in the Kew Herbarium shows conclusively that these represent but a single species. The specific character on which Léveillé relied for the separation of *Hedwigii*, *Friesii* and *penicillata* was the presence of respectively 4, 6 and 8 spores in the ascus. Dealing only with the authentic specimens from Léveillé's Herbarium, we find up to 7 spores in specimens named *Hedwigii*, 4–7 spores in *Friesii*, and 4–8 spores in *penicillata*. It is quite clear, therefore, that the species under consideration must be allowed a range of 4–8 spores. We may note, too, that in these same specimens, the perithecia vary in diameter from 68–110 μ.

Winter (394) has already pointed out that these three species of Léveillé's must be united, and has adopted as the oldest name for the plant *Erysiphe alni* DC., calling the present species, therefore, *M. alni* (DC.) Wint. Unfortunately, this identification is incorrect, as De Candolle's *E. alni* is really the species now known as *Phyllactinia corylea*. De Candolle described his species as follows (Syn. Pl. Fl. Gall. p. 57): "Hypophylla, filamentis plurimis expansis longissimis liberis," and added as a synonym "*Sclerotium Erysiphe alnea* Schl. cent. exs. nr. 68." De Candolle added in Lam. Enc. Méth. (Bot.) 8: 219, these remarks, "Il y a beaucoup de rapport entre cette espèce et la précédente [*Erysiphe coryli* Hedw. = *Phyllactinia corylea*]; elle en diffère par les filaments de sa base, beaucoup plus longs, plus étalés et en plus grand nombre." This description leaves no doubt that examples of *Phyllactinia*

corylea on *Alnus* were under observation. M. Casimir de Candolle has kindly sent me the example of "Schleich. cent. exsicc. n. 68" from De Candolle's herbarium, and the fungus proves to be *Phyllactinia corylea.*

Wallroth was apparently the first to confuse the present species of *Microsphaera* with De Candolle's plant, as this author gives to his *Alphitomorpha penicillata,* var. *alni,* which from the description we recognize as a *Microsphaera;* the synonym *Erysiphe alni* DC. Fortunately, therefore, we can still, by adopting Wallroth's varietal name, retain the specific name *alni* for the present species.

Returning to the study of the various forms of *M. alni* (Wallr.) we find that in American examples the perithecia, which are sometimes (*e. g.,* in certain specimens on *Corylus Americana*) only 66 μ in diameter may reach to as much as 130 μ in diameter on other hosts. In American material, further, the appendages gradually become longer, reaching in rare cases a length of 2½ times the diameter of the perithecium. Also, the branching of the apex of the appendages tends gradually to become more elaborate, reaching its height in the forms on *Cornus* and *Quercus* which have been described as *M. pulchra, M. densissima,* and *M. quercina.*

M. pulchra has already been united by American mycologists to *M. alni,* and there can be no doubt of the correctness of this arrangement. This plant on *Cornus alternifolia* is nevertheless one of the most striking of the American forms, and in its extreme state, with the perithecia 130 μ in diameter, with 17–22 appendages 1½ to twice the diameter, and especially the very ornate apical branching, producing a more or less square outline (Figs. 4–6) seems at first almost worthy of separation. There is, however, no difficulty with sufficient material at hand, in seeing that "*M. pulchra*" is too intimately connected with many American forms of *M. alni.* I have seen specimens on *Alnus incana* from New York with perithecia averaging 120 μ in diameter, with 20–26 appendages, not much exceeding the diameter of the perithecium, but with the apical branching very similar to that of "*M. pulchra.*" Moreover, the large sized perithecia and numerous appendages are not invariably found in "*M. pulchra*" itself; in the type specimen there occur side by side with perithecia 130 μ in diameter, with 16–20 appendages, smaller ones (containing ripe asci) 90 μ in diameter, with only 6 appendages.

M. quercina (Schwein.) Burr. is maintained as a species by Burrill in Ellis and Everhart's N. Amer. Pyrenomycetes. This species on American oaks has been built up out of *Erysiphe quercina* Schwein., *Microsphaera extensa* Cooke and Peck, and *M. abbreviata* Peck.

M. abbreviata Peck, occurring on certain oaks, was described (279) as "allied to *M. Hedwigii* [= *M. alni*], from which it is separated because of the short scabrous appendages." These characters prove wholly insufficient to distinguish this form, and "*M. abbreviata*" may safely be considered a synonym of *M. alni*.

M. extensa Cooke and Peck, however, is a marked plant in its typical form with the long flaccid appendages, and although connected by intermediates with *M. alni*, I consider it is worthy of being separated as a variety.

M. quercina (Schwein.) Burr. has always been recognized as a somewhat unsatisfactory species. Burrill, *e. g.*, says (60, p. 29), "It must be acknowledged that it is well nigh impossible to distinguish some forms referred to *M. alni* from certain specimens placed under *M. quercina*, except by reference to the host-plants." By separating *M. extensa* as a variety, and uniting the other forms on oaks with *M. alni*, from which they do not differ except in occasionally showing a slightly more elaborately branched apex, we get a more natural arrangement of the American forms of *Microsphaera* on *Quercus*.

M. densissima (Schwein.) Cooke and Peck (91) must certainly be referred to *M. alni*. The plant is thus described: "Hyphasma very dense, between filamentose and himantioid, indefinite suborbicular patches ½–2 in. broad, somewhat radiating at the margin, persistent; concepticles few, scattered; appendages 6–10, sporangia 4–8; sporidia 8. Remarkable for the definite orbicular patches of mycelium. On leaves of *Quercus*." In Cooke and Peck's type the persistent mycelium forms definite suborbicular spots on which the perithecia are seated; in all other respects the characters shown are those of ordinary *M. alni*. Curiously in the specimen of "*Erysiphe densissima*" from Schweinitz's herbarium, in Berkeley's herbarium at Kew (which is identical in other respects with Cooke and Peck's specimen, and is accepted as the same species by Cooke), the mycelium is completely evanescent. It is quite

certain that in *M. alni*, as in many species of the Erysiphaceae, the mycelial characters are too variable to be of any systematic value. In an interesting series of specimens in the Kew Herbarium, from the herbarium of W. R. Gerard the mycelium on some leaves is persistent in suborbicular patches, on other leaves subpersistent and more or less effused, finally on others the mycelium is wholly evanescent and the perithecia are seated on the discolored patches of the leaf. Occasionally, too, on other hosts than *Quercus*, *M. alni* shows a persistent mycelium forming definite spots as is seen in certain specimens on *Viburnum*, *Alnus*, etc. The definite suborbicular patches of persistent mycelium could not therefore, even if constant, be considered as distinctive of "*M. densissima.*"

Howe's plant, originally published as *M. sparsa* in the Journal of Botany (91) and later (168) as *M. viburni* (Schwein.) agrees with specimens of *Erysiphe viburni* Schwein. from Schweinitz's herbarium, and does not differ from ordinary *M. alni*. The same is the case with *E. ceanothi* Schwein., *E. syringae* Schwein., *M. platani* Howe, and *M. nemopanthis* Peck.

M. Ravenelii Berk. (on *Gleditschia triacanthos*), since its publication in Grevillea in 1876, has been kept distinct as a species by all authors, but neither in the type-specimen at Kew, nor in the numerous specimens so-named in American collections that I have examined, can I find any characters separating it from *M. alni*. Often the apex of the appendages is only 3 times dichotomously branched (the tips of the ultimate branches are always regularly recurved) and the plant is then identical with the usual European forms of *M. alni;* frequently, however, the apical branching is more elaborate, sometimes even extremely ornate, and then resembles that of American forms of *M. alni* on *Quercus*, *Cornus*, etc. In the type-specimen the appendages are colorless, or sometimes tinged amber-brown at the base. Burrill says "appendages usually hyaline, occasionally colored for a distance, the color ending at an abrupt line like a septum." As mentioned below the occurrence of partially colored appendages is found sporadically in many forms of *M. alni*, and no systematic value can be attached to this character.

M. semitosta Berk. & Curt., on *Cephalanthus*, has, since its publication in Grevillea in 1876, been maintained as a distinct species by

American authors. Examination of Berkeley & Curtis' type in the Kew Herbarium shows the fungus to have these characters: "perithecia 75–100 μ in diameter, appendages 5–9, ¾ to slightly longer than the diameter of the perithecium, with the tips of the ultimate branches, when mature, distinctly recurved; asci and spores as in *M. alni*. The appendages are mostly tinged amber-brown in the lower half, and under low magnification there often seems a sharp line of demarcation between the colored basal part and the colorless upper portion. This appearance however, is due merely to the presence of air in the colored basal part, and is common to several species of *Microsphaera* and *Uncinula*. Sometimes, however, the appendages are faintly colored throughout, and the plant then shows much resemblance to "*M. erincophila* Peck," a form discussed below. Apart from the more or less colored appendages the form on *Cephalanthus* is quite similar to many examples of *M. alni* on other hosts, especially to the small form called by Léveillé "*M. Hedwigii*."

Burrill & Earle (61, p. 414) in their key to the genus *Microsphaera* place *M. semitosta* is the section "Tips of the appendages not recurved," and *M. alni* in the section "tips recurved when mature." Burrill, too, says of *M. semitosta*, "tips obtuse not recurved." The mature apex, however, certainly shows recurved tips, and is, in all the specimens I have seen, quite similar in all respects to that of *M. alni*.

It is worthy of note that Burrill says "primary branches long"; so that it appears that the form on *Cephalanthus* sometimes shows the same kind of variation from the type as do the Japanese forms mentioned later.

The only peculiarity, then, that distinguishes *M. semitosta* is the more or less colored appendages. This character is, I am quite convinced, insufficient to separate it from *M. alni*, being one which, in the forms of this species, cannot be considered of any systematic value. In specimens of *M. alni* on *Carya sulcata* (Urmeyville, Indiana, Coll. E. M. Fisher, 1890. Ex-Herb. U. S. Dept. Agric. n. 1148 (specimen now in the Kew Herbarium)) the appendages are usually colorless, or only fairly tinged, but occasionally here and there one appendage shows a sharply marked off colored basal part like that which occurs in the *Cephalanthus* form.

In certain specimens of *M. alni* on *Vicia Americana* (usually named "*M. Ravenelii*" in herbaria) just the same occasional coloring of the appendages is found. In otherwise typical specimens of *M. alni* on various hosts I have frequently met with an occasional colored appendage, *e. g.*, in certain specimens on *Platanus occidentalis* the coloring is limited by a septum-like line exactly as in "*M. semitosta*"; and the same is the case, although rarely, with examples on *Betula alba*, where the coloring may extend to three-quarters the length of the appendage.

M. erineophila Peck * is another with colored appendages which cannot, it appears, be considered distinct from *M. alni*; Peck, in the original description, says "closely related to *M. penicillata* [*M. alni*], of which perhaps it may be a mere variety, but it is readily distinguished by its colored appendages and nucleated spores." The "nucleate" appearance of the spores may be safely disregarded as a character, and we have then only the colored appendages as a supposed distinctive character separating the plant from *M. alni*. Relying on this point, subsequent American authors have kept up *M. erineophila* as a distinct species. I cannot follow this arrangement. In the first place, as mentioned above, we find quite commonly in ordinary *M. alni* the base of the appendages becoming colored, and in the form described as "*M. semitosta*" the color usually reaches to half the length of the appendage. In a form of *M. alni* on *Carya alba* (Rab.-Wint.-Pazsch. Fung. Eur. 3953) the perithecia are exactly similar in size, and in the number and length of the appendages, to those of "*M. erincophila*," but as regards the coloring of the appendages are intermediate. The appendages of some perithecia are quite colorless, of others tinged amber brown throughout. If we were to separate the form "*M. erineophila*" from *M. alni*, the plant on *Carya alba* would certainly have to be included under the former—the appendages consequently would have to be considered as varying from colorless to colored, and in the former case the plant would only be characterized by the small size, short appendages, etc.—characters which, as we have seen in the case of *M. Hedwigii*, are quite insufficient.

With regard to *M. erincophila* on *Fagus ferruginea* there seems some connection between the coloring of the appendages

* On "erineum"—galls on the leaves of *Fagus ferruginea*.

and the occurrence of the fungus on the "crineum," as we find a form of it with uncolored appendages, but otherwise certainly indistinguishable, on the leaves of the same host-plant when no galls are present.

On the other hand the colored-matter appears in the appendages of [illegible] on other hosts without the occurrence of [illegible] this species in the Kew Herbarium [illegible] later on [illegible] and [illegible] this specimen was labelled [illegible] E. M. [illegible] Natural Indiana. E. M. [illegible] the material crosses of [illegible] crineum, or them [illegible] the leaves, however, the [illegible] other agents [illegible] [illegible] appendages [illegible] [illegible] appendages [illegible] [illegible] and the [illegible] when it [illegible]

Menispermum Canadense. The form on this host-plant has been described as a distinct species, *M. menispermi* E. C. Howe.

Burrill (60), in his critical work on the American species of *Microsphaera*, has maintained *M. menispermi* as a distinct species. "Remarkable for the variation in structure and size. In some perithecia only one ascus is found, while in others in the same microscopical preparation at least seven have been seen. The appendages on a single perithecium are somewhat equal in length, but are often exceedingly variable in the division of the tips. Sometimes there is only a single fork with two equal, straight, obtuse branches, and again, the exceedingly ornamental tips fill the field of the microscope with its complex scroll-work."

I am indebted to Professor Underwood for sending me an authentic specimen of *M. menispermi* from the Ellis Herbarium. Examination of this specimen (now in the Kew Herbarium) showed that without doubt the fungus must be referred to *M. alni*, and, judging from this specimen alone, it cannot be considered even a marked form of this variable species. The specimen showed these characters, mycelium evanescent, perithecia more or less scattered, 100–135 μ in diameter, appendages 12–20, about equalling the diameter of the perithecium, colorless, apex 4–6 times closely and regularly dichotomously branched, tips of ultimate branches regularly and distinctly recurved, asci 4–8, spores 4–8. The branching of the apex of the appendages is often very ornate, but corresponds exactly with that of many common American forms of *M. alni*. From some of the characters given by Burrill in his description—*e. g.*, appendages sometimes seven times the diameter of the perithecium—it seems just possible that some other plant may have been under observation. However this may be, it is safe to consider *M. menispermi* E. C. Howe as a synonym of *M. alni*, as is seen by the characters shown by these authentic specimens (collected by Howe), which agree, moreover, exactly with Howe's original description.

There is a specimen in the Kew Herbarium labelled "*Microsphaera*, on *Populus*, New York, Gerard, 130." The fungus on this is *M. alni*, and the host-plant *P. grandidentata*. *M. alni* has not been reported on *Populus*, and in the present case I feel doubtful whether the perithecia originally grew on the leaves, or have

simply adhered to them. A few perithecia of *Phyllactinia corylea* occur also.

Professor Miyabe has sent me specimens (now in the Kew Herbarium) of two very interesting forms of *M. alni* from Japan. These specimens, while certainly belonging to *M. alni*, are valuable in showing what marked variations occasionally occur. The first of these forms (on *Ligustrum medium*) has often quite colorless appendages and the compact apical branching characteristic of *M. alni;* in many perithecia, however, the apex of some of the appendages forks widely, the primary branches being sometimes quite long. Not infrequently, also, the appendages are colored brown near the base, and a few perithecia were observed in which the color, although faint, reached to the base of the apical branching. The other form, on *Corylus rostrata*, var. *Mandshurica* is more remarkable, and, taken by itself, might certainly be considered distinct. The appendages of most perithecia are rather long, often twice the diameter of the perithecium, and are multiseptate and uniformly colored brown to the commencement of the apical branching. The apical branching is rather irregular, the primary branches being frequently long. Nevertheless, even in this form with usually strongly colored appendages, we get occasionally colorless appendages, and a small compact apex branched in the normal manner for *M. alni*. The wide branching of some of the appendages of these two forms tends to connect them with the var. *divaricata*, while the quite sporadic appearance of colored appendages shows that, in *M. alni*, no value can be attached to this character.

Magnus (227) in an interesting and well-illustrated paper on the forms of *M. alni*, comments on the curious fact that this species is abundant on *Syringa vulgaris* in North America, while no record exists of its occurrence on this host in Europe.

Var. **lonicerae** (DC.) [Figs. 19–22]

Erysiphe lonicerae DC. Fl. Fr. **6**: 107. 1815; Tul. Sel. Fung. Carp. **1**: 205. *pl. 2. f. 4.* 1861.

Alphitomorpha divaricata, var. *lonicerae* Schlecht. Berl. Ges. Nat. Freund. Verh. **1**: 49. 1819.

Erysibe divaricata, var. *lonicerae* Lk.; Willd. Sp. Pl. **6**: 113. 1824.

Erysiphe penicillata, var. *lonicerae* Fr. Syst. Myc. **3**: 244. 1829.

E. divaricata, var. *lonicerae* Duby, Bot. Gall. **2**: 871. 1830.

E. divaricata Lk.; Johnst. Fl. Berw. **2**: 142. 1831.

Alphitomorpha penicillata, var. *caprifoliacearum* Wallr. Fl. Crypt. Germ. **2**: 754 (partim). 1833.

Erysiphe penicillata Kickx. Fl. Crypt. Env. Louv. 138 (partim). 1835; Berk. in Sm. Engl. Fl. **5**: 327 (partim). 1836.

Erysibe penicillata, var. *caprifoliacearum* Rabenh. Deutsch. Krypt. Fl. **1**: 236 (partim). 1844.

Microsphaera Ehrenbergii Lév. Ann. sci. nat. III. **15**: 155. *pl. 8. f. 22* (sub *Calocladia*). 1851; Sacc. Syll. Fung. **1**: 14. 1882; Wint. in Rabenh. Krypt. Fl. Deutschl. **1²**: 39. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 92. 1885; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 244. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 748. 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 93. 1897.

M. Dubyi Lév. Ann. sci. nat. III. **15**: 158. *pl. 9. f. 26* (sub *Calocladia*). 1851; Sacc. Syll. Fung. **1**: 10. 1882.

Calocladia Ehrenbergii Lév.; Dietr. Blick. Crypt. Ostseeprov. 336. 1856; Karst. Myc. Fenn. **2**: 195. 1873.

Microsphaera lonicerae (DC.) Wint. Rabenh. Krypt. Fl. Deutschl. **1²**: 36 (excl. syn. *E. abnormis* Duby). 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 91. 1885; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 243. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 747. 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 89. 1897.

Exsicc.: Bri. & Cav. Fung. par. 71; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 1111, *ed. 2, ser. 1, 511; Kunze, Fung. Select. Exsicc. 319; Sacc. Myc. Ven. 891; de Thüm. Myc. univ. 450, 1056; Roumeg. Fung. Gall. Exsicc. 767, 827, 1540, 3938; Syd. Myc. March. 735, *3722, *3919; Rehm. Ascom. 349, 847; Zopf. & Syd. Myc. March. 83; Westend. Herb. Crypt. Belg. 1388; and 112 (a only) (in Herb. Jard. bot. Bruxelles), de Thüm. Fung. austr. 135; Oudem. Fung. Weerl. Exsicc. 154; Fckl. Fung. Rhen. 696; Rab.-Wint. Fung. Eur. 2651; Rab. Fung. Eur. *556; and 296 sub *M. Hedwigii*; *Erikss. Fung. par. scand. exsicc. 144, 235; Rab. Herb. Myc. ed. 2, 473.

Amphigenous; mycelium usually subpersistent and effused over the surface of the leaf, or forming patches, sometimes evanescent; perithecia gregarious or scattered, globose, depressed, very variable in size, 60–105 μ in diameter, cells 8–14 μ wide; appendages 4–30, ¾ to twice the diameter of the perithecium, colorless, smooth, aseptate or rarely 1-septate and brownish towards the base, thin-walled above, becoming thick-walled towards the base, apex 3–4 times more or less closely dichotomously branched, (rarely trichotomously branched in the branching of the first and second orders), tips of the ultimate branches mostly straight, occasionally one here and there recurved; asci 2–7, usually about 4, broadly ovate to globose, 40–56 × 34–48 μ, with or without a short stalk; spores 3–6, 20–24 × 10–12 μ.

Hosts.—*Lonicera alpigena*, *L. Caprifolium*, *L. flava*, *L. hispida* (95), *L. implexa*, *L. lutea*, *L. nigra*, *L. Periclymenum*, *L. tatarica*, *L. Xylosteum*, *Syringa vulgaris* (3) (227).

Distribution.—EUROPE: France, Belgium, Netherlands, Germany, Switzerland, Italy, Austria-Hungary, Sweden, Finland, Russia.

The present plant differs from *M. alni* only in the usually more loosely branched apex, with the tips of the ultimate branches for the most part straight, with occasionally one here and there recurved. At first view, one is inclined, from analogy, to consider these few recurved tips as the mature form, and to dismiss the straight ones as immature. Examination of considerable material shows, however, that this view cannot be taken, and that the recurved form is really in the present plant the exceptional one.

The extreme form of the var. *lonicerae* with a loosely and rather vaguely branched apex, with the ultimate branches more or less unequal, and their tips all straight, is very different from typical *M. alni* with its compact apex and regularly recurved tips. This is the form described by most authors, who consequently place the plant in the section of the genus characterized by having the tips of the ultimate branches not recurved. Léveillé describes this form (under the name of *M. Dubyi*), and figures the apex of the appendages as very unlike that of *M. alni*. Nevertheless, in the two specimens of "*M. Dubyi*," on *Lonicera Caprifolium* and *L. Xylosteum*, at Kew, from this author's herbarium, some perithecia may be found in which the appendages have the tips of the ultimate branches distinctly (although only here and there) recurved.

Léveillé described the plant on *Lonicera tatarica* as a distinct species—*M. Ehrenbergii*, but it is certainly not distinct from that on *L. Caprifolium*, etc. Specimens on *L. tatarica* have, perhaps, more often recurved tips here and there, and a slightly more compact branching of the whole apex, and shorter appendages than those on *L. Caprifolium*, etc., but these characters are certainly not invariable, and are, besides, frequently met with in, *e. g.*, the plant on *L. Xylosteum*, which has always been referred by authors, including Léveillé, to *Dubyi*.

The size of the perithecium and number of the appendages are very variable; I have seen perithecia, side by side on a leaf, 70 μ in diameter with 5 appendages, and 105 μ in diameter, with 22 appendages.

The var. *lonicerae* is confined to Europe; the numerous records of the plant on species of *Lonicera* in America all refer to typical *M. alni*. This is the case with Cooke and Peck's record of "*M. Dubyi*" in the Journal of Botany (90, p. 13); with Peck's records in the 26th and 29th Reports of the N. York St. Mus. (278 and 280) on *Lonicera glauca*, etc., and Saccardo's record of "*M. Dubyi*" from North America on *L. parviflora*. In these American specimens, and in the numerous other ones that I have seen in herbaria (including one named "*M. finitima* Howe," in the Kew Herbarium), the fungus clearly belongs to *M. alni*, and shows no approach whatever to the var. *loniccrae* of European honeysuckles. The apex is very ornate with regularly and distinctly recurved tips, in fact, many of the specimens show exactly the same elaborate type of branching as that of "*M. pulchra*," a form of *M. alni* on *Cornis alternifolia*.

The present plant can scarcely claim a higher rank than that of a variety of *M. alni*. Not only do we frequently find some of the tips of the ultimate branches here and there recurved, but further proof of affinity with *M. alni* is shown by the occurrence, although only very rarely, of an apex in which all the tips are recurved, and which taken by itself, would pass for that of *M. alni*. This is found, *e. g.*, in the specimens in Oudem. Fung. Neerl. Exsicc. no. 154.

As we know that *M. alni* is an extremely variable plant, all the above facts lead us to the conclusion that this species has pro-

duced on European honeysuckles a variety, *lonicerae*, characterized by a slightly different branching of the apex, but which occasionally shows signs of reverting to the type.

It is, perhaps, of interest to note that in an immature condition, the apex of the appendages of *M. alni*, is often exactly similar to the mature apex of the var. *lonicerae*.

Allescher (3) has recorded "*Microsphaera Ehrenbergii*" on *Syringa vulgaris* from Bavaria, and has stated that the *Syringa* affected stood in the immediate neighborhood of a bush of *Lonicera tatarica* attacked by the same fungus. Magnus (227, p. 68) has confirmed the identification, and considers the case to afford conclusive proof that the variety *lonicerae* (= *M. Ehrenbergii*) has here passed over from the *Lonicera* to the *Syringa*. The figure which Magnus gives (loc. cit., *f. 16*) certainly seems to represent the apical branching of the var. *lonicerae* rather than that of *M. alni* proper, a species which occurs very commonly on *Syringa* in North America.

The present variety *lonicerae* has hitherto been supposed to be the only *Microsphaera* which occurs on *Lonicera* in Europe; the occurrence of *M. alni*, var. *divaricata* on *Lonicera caerulea* in Italy is noted later.

Var. **divaricata** (Wallr.). [Figs. 23–26]

Alphitomorpha divaricata Wallr. Berl. Ges. Nat. Freund. Verh. **1** : 39. 1819; Wallr. Fl. Crypt. Germ. **2** : 754. 1833.

Erysibe divaricata, var. *frangulae* Lk.; Willd. Sp. Pl. **6** : 113. 1824.

E. divaricata (Wallr.) Schlecht. Fl. Berol. **2** : 169 (partim). 1824; Rabenh. Deutschl. Krypt. Fl. **1** : 236 (excl. syn. *Erysiphe Daphnes* Duby). 1844.

Erysiphe penicillata, var. *rhamni frangulae* Fr. Syst. Myc. **3** : 244. 1829.

E. divaricata, var. *frangulae* (Lk.) Duby, Bot. Gall. **2** : 870. 1830.

E. divaricata (Lk.) Secret. Mycogr. Suisse, **3** : 653. 1833.

Microsphaera divaricata Lév. Ann. sci. nat. III. **15** : 155. *pl. 8. f. 18* (sub. *Calocladia*). 1851; Sacc. Syll. Fung. **1** : 11. 1882; Wint. Rabenh. Krypt. Fl. Deutschl. **1²** : 38. 1884;

Karst. Act. Soc. Faun. Fl. Fenn. **2** : 91. 1885; Schroet.; Cohn's Krypt. Fl. Schles. **3** : 242. 1893; Jacz. Bull. l'Herb. Boiss. **4** : 749. 1896.

Calocladia divaricata Lév.; Dietr. Blick. Crypt. Ostseeprov. 335. 1856; Karst. Myc. Fenn. **2** : 195. 1873.

EXSICC.: Fckl. Fung. Rhen. 689; Syd. Myc. March. 337; Karst. Fung. Fenn. Exsicc. 279; de Thüm. Myc. univ. 2151; Roumeg. Fung. select. exsicc. 4758; *de Thüm. Fung. austr. 140; *Westend. & Wall. Herb. Crypt. Belg. 1387; *Erikss. Fung. par. scand. 141; *Erbar. Critt. ser. 1, 142 (sub *Erysiphe lonicerae*).

Amphigenous; mycelium evanescent or subpersistent and more or less effused, or forming definite patches; perithecia gregarious or scattered, variable in size, 72–136 μ in diameter, cells 10–18 μ wide; appendages 4–16, 1 ½–5 ½, usually 3–4 times the diameter of the perithecium, flaccid when long, smooth, thin-walled above, becoming thick-walled at base when nature, colorless and aseptate, or 1–3-septate in the lower half, and then usually dark brown towards the base, apex 2–4 times dichotomously branched, primary branches usually long, divergent, and often recurved, tips of ultimate branches recurved; asci 3–7, broadly ovate to globose, usually very shortly stalked, 28–48 × 30–38 μ; spores 4–6, 18–23 × 9–12 μ.

Hosts.—Lonicera caerulea, Rhamnus Frangula.

Distribution. — EUROPE: France (307), Belgium, Germany, Italy, Austria-Hungary, Denmark, Norway, Sweden, Finland, Russia.

In its extreme form, when the appendages are long, and the apex is divided into long primary and secondary recurved branches (Figs. 24–26), the present plant seems distinct enough from *M. alni* to claim the position that all recent authors give it as a distinct species. But in the forms where the appendages are shorter—sometimes only 1 ½ times the diameter of the perithecium, the branching of the apex not unfrequently becomes closer (Fig. 23), and a relationship with *M. alni* is then at once apparent. Nevertheless, it would perhaps be possible to consider *M. divaricata* specifically distinct from *M. alni* if we confined ourselves to the study of European examples of the latter, relying for specific characters on the longer, flaccid appendages with a loosely-branched apex in distinction to the short, more or less rigid ap-

pendages with a much more closely and regularly branched apex of *M. alni.*

The study of American examples of *M. alni,* however, at once shows us that we have long-appendaged forms certainly connected with this species; it is impossible, *e. g.,* in face of the numerous intermediates, to regard the plant described as *M. exclusa* Cooke and Peck (a form with very long appendages) as anything but a well-marked variety of *M. alni.*

More than this, there occurs in America a plant on *Vaccinium,* etc., described as *M. vaccinii,* but which must also be regarded as a variety of *M. alni* in which we occasionally find much the same kind of apical branching as in the var. *divaricata.* It is even possible that it will eventually be found necessary to unite the American variety *vaccinii* with the European var. *divaricata.*

Considering these facts, we are forced to the conclusion that in America, where the species is apparently more abundant than in Europe, *M. alni* has varied and produced long-appendaged varieties on several host plants, while in Europe only one very similar variety has been produced on *Rhamnus Frangula.*

A further proof of the relationship of the present plant with *M. alni* is afforded by the Japanese specimens of *M. alni* on *Corylus rostrata,* var. *mandschurica,* which frequently show a loosely-branched apex with spreading branches.

Speshnew (338) records *M. divaricata* on *Rhamnus cathartica* from Transcaucasia. As this plant is a common host for *M. alni,* it will be best to wait for confirmation before accepting this record of the occurrence of *divaricata* in Asia, on a new host-plant.

Since the above remarks were written I have seen examples—one in the Herbarium of the British Museum (South Kensington), and one in the Herbarium of the Florence Museum, of the specimen no. 142 (1142) in the Exsiccati "Erb. Critt. Ital. ser. 1." (Part of the latter specimen is now deposited in the Kew Herbarium.) These specimens are labelled "*Erysiphe lonicerae,*" and the host plant is *Lonicera caerulea.* The fungus, however, is not the species named (which is described above, as *M. alni,* var. *lonicerae*) but belongs to the present variety *divaricata.*

These examples on *Lonicera coerulea* have long flaccid appendages, 4–7 times the diameter of the perithecium, with often the

characteristic apical branching of typical *divaricata;* sometimes, however, the branching is slightly more compact.

This occurrence on a species of *Lonicera* is extremely interesting, as it has been hitherto supposed that the var. *divaricata* was absolutely confined to *Rhamnus Frangula*, and that the only plant which occurred on *Lonicera* in Europe was *M. alni*, var. *lonicerae.*

Var. **vaccinii** (Schwein.).

Erysiphe vaccinii Schwein. Syn. Fung. Am. Bor. 270. 1834; Sacc. Syll. Fung. **1**: 21. 1882.

Microsphaera vaccinii Schwein. Cooke & Peck Journ. of Bot. II. **1**: 13. 1872; Peck, Reg. Rep. **23**: 65. 1873; Sacc. Syll. Fung. **1**: 13. 1882; Burr & Earle in Bull. Ill. State Lab. Nat. Hist. **2**: 417. 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 70. 1891; Burr. in Ell. & Everh. N. Amer. Pyren. 25. 1892.

M. elevata Burr.; Bull. Ill. State Lab. Nat. Hist. **1**: 58. *pl. 2. f. 4, 5.* 1876; Sacc. Syll. Fung. **1**: 770. 1882; Burr & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 427. 1887; Sacc. Syll. Fung. **9**: 369. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 26. 1892.

Exsicc.: Ell. North Amer. Fung. 430; Rab.-Wint. Fung. Eur. 3539; *Seym. & Earle, Econ. Fung. 145; *Ell. & Everh. Fung. Columb. 506.

Epiphyllous, rarely amphigenous; mycelium persistent, very thin and effused over the upper surface of the leaf, or forming irregular patches, sometimes completely evanescent; perithecia globose or globose-depressed, more or less scattered, very variable in size, 70–145 μ in diameter, cells 10–20 μ wide; appendages 4–22, 2½–8 times the diameter of the perithecium, rather delicate and thin (about 5 μ wide), sometimes slightly angularly bent, flexuose, flaccid, colorless or occasionally amber-brown at the base, smooth or sometimes slightly rough towards the base or for most of the length, aseptate thin-walled above, becoming thick-walled below when mature, apex 2–4 times dichotomously branched, branching variable, sometimes very close and compact, sometimes widely forked, with the primary branches long and occasionally recurved, tips of ultimate branches regularly and distinctly recurved; asci 2–16, 45–72 × 28–38 μ, ovate or ovate-oblong, with or without a short stalk; spores 4–6, 18–22 × 10–13 μ.

Hosts.—Andromeda sp., *Catalpa bignonioides, C. speciosa, Epigaea repens, Gaylussacia resinosa, Lyonia paniculata* (371),

Vaccinium Canadense, *V. Myrtillus*, vars. *macrophyllum* and *microphyllum* (151), *V. Pennsylvanicum*, *V. vacillans*.

Distribution.—NORTH AMERICA: United States—New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Maryland, West Virginia, (249) North Carolina, Ohio, Michigan, Indiana, Alabama, Illinois, Wisconsin, Missouri, Iowa, Wyoming. Canada—Ontario.

The present plant is extremely variable in nearly all its characters.

Schweinitz, in 1834, first described the plant as growing on *Vaccinium Pennsylvanicum*, as *Erysiphe vaccinii;* in 1872 Cooke & Peck described a plant on *Vaccinium vacillans* as *Microsphaera vaccinii*, giving *E. vaccinii* Schwein. (partly) as a synonym.

Burrill has maintained *M. vaccinii* (Schwein.) Cooke & Peck as a species, and has described the appendages as "6–20, hyaline, smooth, slightly colored at base, 2 or 3 to as many as 6 times the diameter of the perithecium, branching various, usually 3 or 4 times forked, with the tips truncate or bifid, not recurved, occasionally more ornate, with tip distinctly recurved. This is a variable species not only in the character of the mycelium, but in the length and branching of the appendages. In most cases the tips are swollen and not at all recurved."

I am indebted to Professor Earle, Professor Ellis, Professor Underwood, and other American botanists for numerous specimens of the American forms of *Microsphaera* on *Vaccinium* and *Epigaea*.

In the first place, it is evident, from the study of these, that it is incorrect to consider, as has been hitherto done in America, all the forms that grow on species of *Vaccinium* as belonging to "*M. vaccinii*." On *E. corymbosum* the only fungus that I have seen is certainly to be referred to *M. alni* type; this is, no doubt, the plant recorded by Cooke & Peck (90, p. 12) as "*M. Friesii* Lév. var. *vaccinii*."

On other species of *Vaccinium*, however, and on *Epigaea*, the fungus differs from *M. alni* in having long, very flaccid, thinner appendages, with the apical branching much more variable. Burrill's description of the tips of the ultimate branches as "truncate or bifid, not recurved" undoubtedly refers to the immature condition only.

On the whole, the present plant appears clearly marked off from typical *M. alni* by the long flaccid appendages, and their usually more irregularly branched apex. It is more difficult to separate it from *M. alni* var. *extensa*. I do not think it advisable at present, however, to unite these two forms. In the var. *vaccinii* the apex of the appendages is almost constantly more irregularly and widely branched than that of the var. *extensa*, indeed the primary branches are sometimes long, divergent, and slightly reflexed as in the var. *divaricata*. In the var. *extensa* the apex is usually as ornate and as closely branched as in certain forms of typical *M. alni*. It must, however, be mentioned that cases have occurred, although very rarely, where the apical branching of the var. *vaccinii* has been quite similar to that of the var. *extensa*, and it is certainly possible that these two varieties will eventually have to be united.

I feel no hesitation in considering *M. elevata* Burrill, on *Catalpa*, as a form of the present plant.

At first sight this form, which occurs on *Catalpa bignonioides* and *C. speciosa* appears to have these distinctive characters: smaller perithecia with fewer appendages, and a smaller more closely branched apex. The size the perithecium, however, is certainly variable, not only in this form on *Catalpa*, where it ranges from 70–130 μ in diameter, but also in the plant on *Vaccinium* and *Epigaea*. In Cooke & Peck's type of *M. vaccinii* at Kew, the perithecia, although varying between wide limits, average 115 μ; in other specimens, *e. g.*, those in Ell. N. Amer. Fung. no. 430, the perithecia are smaller, about 95 μ in diameter. In specimens on *Epigaea repens*, in which the apical branching of the appendages is the same as that of the plant on *Vaccinium*, the perithecia are frequently only 85 μ in diameter. As regards the number of the appendages, this is about 14 in Cooke & Peck's type, in Ellis' specimen fewer (7 or 8), and on *Epigaea* frequently only 4 or 5. Nor is the small compact closely-branched apex of the appendages absolutely characteristic of the plant on *Catalpa*, as I have seen just the same characters in a specimen on *Vaccinium* (now in Kew Herbarium) sent to me by Professor Underwood. The same, small, compact apex is also seen in the plant on *Gaylussacia resinosa*, which has been referred by all authors to *M. vaccinii*.

Var. **extensa** (Cooke & Peck). [Fig. 18]

M. extensa Cooke & Peck, Journ. of Bot. II. 1: 12. 1872; Peck, Reg. Rep. 25: 1873; Sacc. Syll. Fung. 1: 13. 1882.

M. quercina (Schwein.) Burr.; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. 2: 424 (partim). 1887; Burr.; Ell. & Everh. N. Amer. Pyren. 28 (partim). 1892.

M. quercina (Schwein.) Burr., var. *extensa* Atkins. Jour. Elisha, Mitch. Sci. Soc. 7: 72. 1891.

EXSICC.: Rab.-Wint. Fung. Eur. 5033; de Thuem., Myc. univ. 756; Kellerm. & Swingle, Kans. Fung. 11.

Epiphyllous; mycelium persistent, effused or forming irregular spots; perithecia more or less densely gregarious, often forming floccose patches 90–140 μ in diameter, averaging 115 μ; cells 10–20 μ wide; appendages 8–19, 2½–6 times the diameter, of the perithecium, rather delicate, flexuose, flaccid, narrow (about 5 μ wide), sometimes slightly angularly bent, usually smooth, occasionally rough at the base, colorless, aseptate, thin-walled throughout, or rarely becoming thick-walled towards the base, apex 3–5 times more or less closely dichotomously branched, tips of ultimate branches regularly and distinctly recurved; asci 3–8, ovate or broadly ovate, shortly stalked, 58–72 × 34–45 μ; spores 4–8, usually 6, large, 22–26 × 12–15 μ.

Hosts.—Quercus alba, Q. discolor, Q. nigra, Q. palustris, Q. rubra.

Distribution.—NORTH AMERICA: United States—Massachusetts, New York, Pennsylvania, New Jersey, North Carolina (9), Indiana, Illinois, Wisconsin, Missouri, Kansas.

The variety *extensa* differs from the type in the longer, narrower, flaccid appendages and slightly larger spores. The branching of the apex is not as a rule different from that of certain forms of *M. alni*, and is much closer and more elaborate than that of the var. *vaccinii*. Cases occur, however, although rarely, in which the manner of branching of the apex is the same in these two plants; the var. *vaccinii* can then be separated by its larger spores.

The present plant was described as a species, *M. extensa*, by Cooke & Peck, but there can be no doubt that it is too close to *M. alni* to be allowed this position. In its well-marked state the appendages are about 4½ times the diameter of the perithecium, flaccid, and narrow, and so appear very different from the stouter

(7 μ wide), more or less rigid appendages of *M. alni*. Certain specimens, however, especially some on *Quercus alba*, show all intermediate stages between *M. alni*, and the var. *extensa*, and in these it is clearly seen that as the appendages become shorter they become, *pari passu*, stouter, and gradually pass into those of ordinary *M. alni* as it occurs on oaks. The specimens in Ellis' N. Amer. Fungi, no. 429, show such intermediate stages between *M. alni* and the var. *extensa*.

Hosts.—*Quercus aquatica*, *Q. laurifolia*, *Q. nigra*.

Distribution.—NORTH AMERICA: United States—South Carolina, Alabama, Florida.

The peculiar variation of growth shown in the axial elongation of the apex of the appendages constitutes a striking character at first sight (see Figs. 15–17), and one which might, if constant, be considered of specific value.

The character, however, is certainly not invariable. On the perithecia of specimens belonging to the var. *calocladophora*, we quite commonly find single appendages which show the same regularly dichotomous apical branching as that found in the forms of *M. alni* on American oaks.

On the other hand, in certain specimens of otherwise typical *M. alni*, we find a single appendage here and there showing the axial elongation characteristic of the var. *calocladophora*. As an instance of this may be mentioned the specimens in the Herbarium at the British Museum (South Kensington) labelled "*M. extensa*, on fallen leaves of water oak. *Quercus aquatica*, Aiken, South Carolina. H. W. Ravenel, Nov., 1881," and "*M. pulchra*" on *Cornus alternifolia*. In both these specimens, among perithecia with appendages normal for *M. alni*, there occurs rarely a single appendage with the apex formed as in the var. *calocladophora*.

In the face of these connecting links on both sides, it is impossible to consider the present plant as specifically distinct. Underwood and Earle (371, p. 178) have some interesting remarks on this point.

Var. **calocladophora** (Atkins.) [Figs. 15–17]

M. densissima Ell. & Mart. Journ. Myc. 1 : 101. 1885; Sacc. Syll. Fung. Addit. ad. Vols. I.–IV.: 2. 1886 and 9 : 368. 1891.

M. calocladophora Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 73 (cum icon.). 1891; Burr. in Ell. & Everh. N. Amer. Pyren. 29. 1892; Sacc. Syll. Fung. **1**: 253. 1895.

EXSICC.: *Seym. & Earle, Econ. Fung. 179; Rab.-Wint. Fung. Eur. 3538; Ell. & Everh. N. Amer. Fung., sec. ser. 1538; Rav. Fung. Amer. Exsicc. 625, sub *M. extensa*.

Main axis of many of the appendages not dividing dichotomously at the apex, but growing on and bearing sets of opposite branches, which occasionally show the same axial elongation; asci 62–75 × 42–45 μ; spores large, 24–28 × 12–15 μ.

Var. **ludens** var. nov. [Figs. 27–30]

Perithecia more or less densely gregarious; appendages numerous, often crowded, about 1½ times the diameter of the perithecium, usually flexuose-contorted or angularly bent, apex usually very irregularly and widely branched, 4–5 times dichotomous, primary branches usually rather long, and those of the subsequent orders unequal and irregularly placed, with the tips straight; sometimes the branching is closer and more regular, with the tips distinctly recurved; asci and spores as in *M. alni*.

Hosts.—*Vicia Americana* and vars. *linearis* and *truncata*.

Distribution.—NORTH AMERICA: United States—South Dakota (Brookings (D. Griffiths, Aug. 1892) and Snoma (Griffiths and Carter, Aug. 1897)), Wyoming (French Creek, Williams and Griffiths, Aug. 1898).

Among the duplicate specimens (now in the Kew Herbarium) sent to me from the fine collection of Erysiphaceae made by Griffiths in Dakota, Wyoming and Montana there are examples of a *Microsphaera*, growing on the species of *Vicia* named above, which are very difficult to place.

Griffiths has named and recorded this *Microsphaera* as *M. diffusa*. This led me to examine again all the material of *M. diffusa* at my disposal, and to compare them with the present plant.

From all specimens seen of *M. diffusa* Griffiths' plant differs in possessing, frequently, a recurved tip to the ultimate branches. Sometimes we find a single appendage with the tips all regularly and distinctly recurved, and the mode of branching of the whole apex not very unlike that of *M. alni*, and certainly like that of some of its varieties, *e. g.*, var. *divaricata* (Figs. 28, 30). On the other hand a large proportion of the appendages show an apical

branching of a very different type to that of *M. alni*; the branching being very lax and irregular, with straight tips to the ultimate branches (Figs. 27, 29).

In the latter case there is much resemblance to *M. diffusa*, but in that species we find the ultimate divisions (of the mature apex) forming long, rather slender, nearly parallel branches. These long ultimate branches are characteristic of *M. diffusa*, and are not found in the present plant, in which, moreover, as mentioned above, we frequently find some appendages with recurved tips, another character which never occurs in *M. diffusa*.

The appendages of the present plant are usually angularly bent, or even more or less contorted; this character together with that of the great variability in the apical branching, give much the appearance of a "sport"; but as the plant has been collected in three different localities on different host plants, it can hardly be dismissed as this.

M. euphorbiae has the same curiously contorted appendages, but differs in the longer appendages, with very flexuous apical branching, etc. If we consider the bent appendages as a character of the first importance, the present plant should rank as a variety of *M. euphorbiae* rather than of *M. alni*; but it is possible that the more or less contorted growth of the appendages is due, in the present case, merely to the great crowding of the perithecia and the consequent interlacing of their appendages. Moreover, in some perithecia the appendages are nearly or quite straight; this is, however, very exceptional.

Except in the very variable nature of the apical branching, and the contorted appendages, the present plant does not differ from *M. alni*.

The usually very lax and irregular apical branching certainly separates the present plant widely from the ordinary forms of *M. alni*, and it is only the occasional occurrence of appendages with recurved tips and a closer type of branching that has led to its being placed, with some hesitation, as a new variety under *M. alni*.

It may be well here to review the position of these six varieties of *M. alni*. In America we have the four varieties *extensa*, *calocladophora*, *vaccinii*, and *ludens*. The position of these to the type may be stated as follows:

Var. *extensa* is a robust form produced on certain species of oaks, and in its extreme state is very distinct in the long flaccid appendages. The apical branching does not deviate from the ornate type commonly found in American examples of *M. alni* on oaks. The spores appear to be distinctly larger. A complete series of intermediate forms exist connecting this variety with the type.

Var. *calocladophora* is another robust form, similarly confined to certain American oaks. The distinguishing character is the axial elongation shown in the apex of most appendages. The spores are large. Connecting links, both on the side of the variety and of the type, are occasionally found.

Var. *vaccinii* differs from the two varieties mentioned above in the smaller spores, and in the variable nature of the apical branching of the appendages. The long, thin appendages and usually looser apex distinguish it from the type, although as the appendages tend to become shorter, they become stouter, with the apical branching more approaching that of *M. alni*. Certainly allied to the European var. *divaricata*.

Var. *ludens* occurs on *Vicia Americana*, and is known at once by the more or less contorted appendages, with very lax and variable apical branching. The tips of the ultimate branches are very frequently straight.

The two European varieties are *lonicerae* and *divaricata*.

Var. *lonicerae*.—This has perhaps some claim to be considered a distinct species which has been evolved on species of *Lonicera* in Europe, perhaps in the same way as *M. berberidis* has on *Berberis;* to this species, indeed, the present variety shows some affinity. On the other hand, relationship with *M. alni* is shown in the fact that the characteristically straight tips of the var. *lonicerae* are occasionally recurved as in this species.

Var. *divaricata*.—This has hitherto been supposed to be confined to *Rhamnus Frangula;* a single occurrence, however, on *Lonicera nigra* has been noted. In its extreme form this variety is very different from any European forms of *M. alni* in the long, divergent, usually reflexed branches of the apex of the long appendages. Occasionally, however, the appendages are shorter, and the apical branching more like that of *M. alni*. Intermediate forms also

exist. This variety shows great affinity with certain forms of the American var. *vaccinii*.

5. M. GROSSULARIAE (Wallr.) Lév. [Figs. 34, 37 and 43]

Alphitomorpha penicillata, var. *grossulariae* Wallr.; Berl. Ges. Nat. Freund. Verh. **1** : 40. 1819; Wallr. Fl. Crypt. Germ. **2** : 755. 1833.

A. grossulariae Wallr. Ann. Wett. Ges. **4** : 236. 1819.

Erysibe penicillata, var. *grossulariae* Lk.; Willd. Sp. Pl. **6** : 114. 1824; Rabenh. Deutschl. Krypt. Fl. **1** : 236. 1844.

Erysiphe penicillata, var. *grossulariae* Fr.; Syst. Myc. **3** : 244. 1829; Duby, Bot. Gall. **2** : 871. 1830.

E. penicillata Spreng.; Fl. Hal. 581 (partim). 1832; Berk. Sm. Engl. Fl. **5** : 327 (partim). 1836.

Microsphaera grossulariae Lév. Ann. sci. nat. III. **15** : 160. *pl. 9. f. 25* (sub *Calocladia*). 1851; Cooke, Micr. Fung. 220. 1865; Cooke, Handb. Brit. Fung. **2** : 649. 1871; Wint. Rabenh. Krypt. Fl. Deutschl. 1^2 : 37. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2** : 91. 1885; Burr. Ell. & Everh. N. Amer. Pyren. 24. 1892; Schroet. Cohn's Krypt. Fl. Schles. **3** : 244. 1893; Jacz. Bull. l'Herb. Boiss. **4** : 747. 1896; Oudem. Rév. Champ. Pays.-Bas. **2** : 90. 1897.

Calocladia grossulariae (Lév.) Dietr. Blick. Crypt. Ostseeprov. 337. 1856.

Erysiphe grossulariae (Lév.) de Bary, Beitr. Morph. Phys. Pilz., **1** : § xiii. 52. 1870.

Microsphaera Van-Bruntiana Ger. Bull. Torr. Club, **6** : 31. 1875; Sacc. Syll. Fung. **1** : 14. 1882; Atkins. Journ. Elisha Mitch. Sci. Soc. **7** : 71. 1891.

Podosphaera grossulariae (Lév.) Quél. Champ. Jur. Vosg. **3** : 106. 1875.

Exsicc.: Rab. Fung. Eur. 1044; Fckl. Fung. Rhen. 697; Roumeg. Fung. Gall. Exsicc. 1539, 2167; Syd. Myc. March. 734; de Thüm. Fung. austr. 136, 460; Ell. N. Amer. Fung. 769, 1324; Cooke, Fung. Brit. Exsicc. ed. sec. 284; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 1110, *ed. sec., ser. 1, 510; Vize. Fung. Brit. 94; Flor. Gall. et Germ. Exsicc. 598; Rab.-Wint. Fung. Eur. 3247; Rehm. Ascom. 849; *de Thüm. Myc. univ. 2242; *Ell.

& Everh. Fung. Columb. 315; *Erikss. Fung. par. scand. 142; *Krieg. Fung. saxon. 725.

Epiphyllous or amphigenous; mycelium evanescent, or subpersistent, thin and effused on the upper surface of the leaf; perithecia scattered to densely gregarious, globose-depressed, very variable in size, 65–130 μ in diameter, cells 14–20 μ wide; appendages 5–22, 1–1¾ times the diameter of the perithecium, colorless, smooth, aseptate, thin-walled above, becoming thick-walled in the lower half, when mature, apex 4–5 times closely and regularly dichotomously branched, branches of the first and second orders very short, all the segments deeply divided (giving a somewhat digitate appearance to the whole apex), ultimate branches forming a narrow fork, tips not recurved; asci 4–10, broadly ovate or oblong, usually with a very short stalk, 46–62 × 28–38 μ; spores 4–6, very rarely only 3, variable in size, 20–28 × 12–16 μ.

Hosts.—*Ribes floridum* (6), *R. Grossularia*, *R. nigrum* (6), *R. rotundifolium* (6), *R. sanguineum*, *Sambucus Canadensis*, *S. racemosa* and var. *pubescens*.

Distribution.—EUROPE: Britain, France, Belgium, Netherlands (263), Germany, Switzerland, Austria-Hungary, Denmark, Sweden, Finland (196), Russia.

ASIA: Japan.

NORTH AMERICA: United States—Vermont, Massachusetts, New York, Pennsylvania, West Virginia (249), North Carolina (13), Ohio, Indiana, Alabama (12), Illinois, Wisconsin, Missouri, Kansas (386), Montana (6), California (159).

A well-marked species in the deeply divided segments of the appendages. The branches of the first and second orders are very short, so that the divisions of the segments reach nearly to the center, giving a somewhat digitate and very characteristic appearance to the whole apex (see Figs. 34, 35).

The American *M. Van-Bruntiana* (on *Sambucus Canadensis*) is identical with the present species, although in the original description the branches of the appendages are described as "truncate at their apices." When mature, however (Fig. 43), the branches are bifid in just the same manner as in *M. grossulariae*, and the original description was no doubt taken from an immature appendage, such as is shown at Fig. 36, drawn from an American specimen.

M. grossulariae is confined in Europe to *Ribes Grossularia;* in America it attacks several other species of *Ribes*, and also, very frequently, *Sambucus Canadensis* and *S. racemosa.*

Professor Miyabe has sent me specimens on *Sambucus racemosa* var. *pubescens* from Japan. This is the first record of the occurrence of the species in Asia.

In Europe *M. grossulariae* sometimes occurs in such quantities on cultivated gooseberries as to cause a disease. In the Journal of the Board of Agriculture for 1898 (184) it is reported that this disease was very troublesome in England during that year, causing the leaves of the gooseberry-bushes affected to shrivel and fall off. The following notes on prevention and remedies are given: "The leaves from infected bushes should be raked from under them and burnt. . . Any dead leaves remaining on infected trees should be picked off and burned, as far as possible. Where there is a sign of infection the leaves should be dusted thoroughly above and below with very finely powdered sulphur put carefully on with a knapsack powder-distributer on a still, hot, sunny day. Sulphide of potassium diluted with water in the proportion of 2½ oz. of sulphide to five gallons of water, and sprayed over and under the leaves in a fine spray, has been found to be efficacious. This dressing should be applied very early when the leaves are small and young, and should be repeated in about sixteen days." Bordeaux mixture, composed of 3 lbs. of sulphate of copper and 3 lbs. of lime to 25 gallons of water, or if used later in the season when the foliage is strong and fully developed, composed of 4 lbs. of sulphate of copper and 4 lbs. of lime to the same quantity of water, is also recommended.

The American "gooseberry mildew," which attacks chiefly the berries, is *Sphaerotheca mors-uvae.*

6. M. MOUGEOTII Lév. [Figs. 59, 60]

M. Mougeotii Lév. Ann. sci. nat. III. **15**: 158. *pl. 9. f. 24* (sub *Calocladia*). 1851; Cooke, Micr. Fung. 219. 1865; Cooke Handb. Brit. Fung. **2**: 649. 1871.

Erysiphe Mougeotii de Bary, Beitr. Morph. Phys. Pilz. **1**: § xiii. 52. 1870.

Podosphaera Mougeotii (Lév.) Quél. Champ. Jur. Vosg. **3**: 106. 1875.

Microsphaera Lycii (Lasch.) Sacc. & Roum. Michelia, **2** : 310. 1881; Sacc. Syll. Fung. **1** : 10. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. 1^2 : 37. 1884; Schroet.; Cohn's Krypt. Fl. Schles. **3** : 243. 1893; Jacz. Bull. l'Herb. Boiss. **4** : 745. 1896; Oudem. Rév. Champ. Pays.-Bas. **2** : 89. 1897.

EXSICC.: de Thuem. Fung. Austr. 461; Roumeg. Fung. Gall. exsicc. 1165, 2740; Rab. Fung. Eur. 1428; Syd. Myc. March. 837; de Thuem. Myc. Univ. 2152.

Amphigenous; mycelium thin, effused and subpersistent, or evanescent; perithecia usually epiphyllous, sub-gregarious or scattered, globose-depressed, 115–170 μ in diameter, cells obscure, 8–13 μ wide; appendages very numerous and densely crowded, about equalling the diameter of the perithecium, flaccid, thin-walled throughout, aseptate, smooth, colorless, sometimes slightly nodulose, apex 2–3 times dichotomously branched, or occasionally, especially in the branching of the first order, trichotomously divided, branching very loose, irregular, and widely spreading, tips of ultimate branches not recurved; asci 10–18, ovate or ovate-cylindrical, often somewhat truncate at apex, shortly stalked, 48–56 × 24–30 μ; spores 2, 20–24 × 12–15 μ.

Hosts.—*Lycium barbarum*, *L. Europaeum*, *L. ovatum* (56)(319), *L. ruthenicum* (307) (394).

Distribution.—EUROPE: Britain, France, Belgium (44) (209), Netherlands (263), Germany, Italy (307), Austria-Hungary, Russia, (172).

A very distinct plant, differing from all other species of the genus in the densely crowded, widely branched appendages and the 2-spored asci.

The appendages at first spread upwards, so that the perithecium, seen from above, appears enveloped in a white mycelium-like mass; eventually the appendages become reflexed, and the exposed upper half of the perithecium becomes concave. The appendages usually branch at about half their length, and fork widely, measuring from 100–150 μ across the apex.

M. Mougeotii is confined to Europe; the species recorded under this name from North America proves to be *M. diffusa*.

Saccardo and Roumeguere, followed by all modern authors, uses the name *M. Lycii* (Lasch.) for the present species. This name, however, published in Sacc. Fung. Gall. ser. III. no. 1174 (1850),

was not accompanied by a diagnosis, and therefore cannot take precedence over Léveillé's name *Mougeotii* (1851).

7. M. DIFFUSA Cooke & Peck. [Figs. 31–33]

M. diffusa Cooke & Peck, Journ. of Bot. II. **1**: 13. 1872; Peck, Reg. Rep. **25**: 95. 1873; Sacc. Syll. Fung. **1**: 12. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 416. 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 69. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 24. 1892.

M. symphoricarpi E. C. Howe, Bull. Torr. Club, **5**: 3. 1874; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 417. 1887; Sacc. Syll. Fung. **9**: 369. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 24. 1892.

Exsicc. (sub *M. diffusa*): Ell. & Everh. N. Amer. Fung. sec. ser. 1540; Rab.-Wint. Fung. Eur. 3654; Rav. Fung. Amer. Exsicc. 628. (Sub *M. symphoricarpi*); Rab.-Wint. Fung. Eur. 3655; Ell. N. Amer. Fung. 768; Rehm. Ascom. 846; *Ell. & Everh. Fung. Columb. 224.

Amphigenous; mycelium persistent, thin and effused, or subpersistent and forming vague patches, or quite evanescent; perithecia scattered or gregarious, globose-depressed, very variable in size, 55–126 μ in diameter, averaging 90–100 μ, cells 10–20 μ wide; appendages very variable in number and length, 4–30, or rarely crowded and as many as 50, 1½–7 times the diameter of the perithecium, smooth, aseptate or 1–3-septate in the lower half, colorless or pale brown towards the base, flaccid when long, thin-walled above, becoming thick-walled towards base, apex 3–5 times dichotomously or sub-dichotomously divided, branching diffuse and irregular, branches of the higher orders sub-nodulose, often apparently lateral, tips of ultimate branches not recurved; asci 4–9, 48–60 × 28–30 μ, ovate-oblong with a very short stalk; spores 3–6, usually 4, 18–22 × 9–11 μ.

Hosts.—(Sub *M. diffusa*) *Apios tuberosa, Desmodium Canadense, D. canescens* (265) (324) 366), *D. cuspidatum* (61), *D. paniculatum, D. sessilifolium, Glycyrrhiza lepidota, Lespedeza capitata, L. hirta, L. striata, L. violacea, Phaseolus perennis.* (Sub *M. symphoricarpi*) *Symphoricarpos occidentalis, S. orbiculatus, S. racemosus* and var. *pauciflorus* (6).

Distribution.—NORTH AMERICA: United States (sub *M. diffusa*) —Connecticut, New York, Pennsylvania, South Carolina, Ohio

(324), Michigan, Alabama, Illinois, Mississippi, Wisconsin, Missouri, Iowa, Minnesota, South Dakota, Kansas, Montana, Wyoming. (Sub *M. symphoricarpi*) Pennsylvania, Virginia, Ohio, Indiana, Illinois, Missouri, North and South Dakota, Kansas, Montana, Idaho, Colorado, California, Washington.

A species very variable in every character except the irregular diffuse branching of the apex of the appendages, in which a good specific distinction is found. The dichotomous nature of the branching ceases in the higher orders, so that the youngest branches are irregularly arranged, and often appear as lateral outgrowths; a slightly nodulose appearance of the branches is also characteristic of the present species (see Figs. 31, 32).

After seeing a large amount of material, I feel convinced that the plant on *Symphoricarpos—M. symphoricarpi*, E. C. Howe, should be referred to *M. diffusa*. In this form the perithecia are perhaps slightly smaller on the average, although the size varies greatly (I have seen contiguous perithecia on a leaf measuring 55 μ and 104 μ in diameter); the appendages are usually fewer (4–24), and tend to become longer than in typical *M. diffusa;* but these characters are not constant. In certain specimens on *Symphoricarpos*, perithecia taken from the same leaf show a variation in the length of the appendages of from 1 ½ to 7 times the diameter of the perithecium; while, on the other hand, *M. diffusa* on other host-plants frequently possess appendages reaching to four times the diameter of the perithecium,* and as few as 12 in number. In the peculiar character of the apical branching of the appendages the form on *Symphoricarpos* agrees well with *M. diffusa*, and as this is, I consider, the most important specific character, I feel little hesitation in treating the two plants as one species. It is necessay to point out that in the form on *Symphoricarpos* the appendages are very slow in reaching their full development, and unless perfectly mature examples are examined, the apex of the appendages appears less diffusely branched. In specimens with a fully developed apex, however, as is the case, *e. g.*, with those on *S. occidentalis* (Fort Collins, Colorado (C. F. Baker)) and on *S. racemosus* (Datah Co., Idaho, June, 1897 (L. F. Henderson)) both

* Burrill & Earle (61, p. 417) mention specimens on *Lespedeza capitata* with appendages "5 or 6 times the diameter."

in Professor Earle's Herbarium—the identity in the nature of the apical branching of the form on *Symphoricarpos* and of *M. diffusa* on other hosts is clearly seen.

Burrill (60) remarks on "*M. symphoricarpi* (which is given specific rank)"; "much like some forms of *M. vaccinii*." The latter plant is, however, far removed in the distinctly recurved tips of the ultimate branches of the apex of the appendages.

M. diffusa has been recorded on *Lathyrus ochroleucus* by Burrill (60) and Trelease (366). From the remarks of the latter author, however, that the appendages were "absolutely indistinguishable from those of *M. pulchra*" there can be no doubt that the fungus was really *M. alni*. *Vicia* is also given as a host-plant by Burrill (60) for the present species, but it seems probable that *M. alni*, var. *ludens* has been mistaken for *M. diffusa* in this case. I have seen specimens of typical *M. alni* on both *Lathyrus ochroleucus* and *Vicia Americana*.

The records of *M. Mougeotii* Lév. (*M. Lycii*) from America belong to the present species.

8. M. RUSSELLII Clinton. [Figs. 38, 39]

M. Russellii Clinton; Peck, Reg. Rep. **26**: 80. 1874; Sacc. Syll. Fung. **1**: 12. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 415. 1887; Burr.; Ell. & Everh. N. Amer. Pyren. 23. 1892.

EXSICC.: Ell. & Everh. N. Amer. Fung. sec. ser. 2008, 3517; *Seym. & Earle, Econ. Fung. 270a, 270b;* Ell. & Everh. Fung. Columb. 507.

Amphigenous; mycelium evanescent, or subpersistent; perithecia scattered, 70–118 μ in diameter, globose-depressed, cells small, 6–14 μ wide; appendages 5–14, 3–7 times the diameter of the perithecium, flaccid, septate, smooth, colored nearly to the apex when mature, apex 2–4 times dichotomously branched, branching very irregular and lax, primary branches usually long and forking widely, tips of ultimate branches not recurved; asci 4–9, narrowly to broadly ovate, or (in small perithecia) ovate-globose, shortly stalked, 42–56 × 24–32 μ; spores 3–5, usually 4, 18–22 × 10–12 μ.

Hosts.—*Oxalis corniculata*, var. *stricta*, *O. Suksdorfii*, *O. violacea* (60).

Distribution.—NORTH AMERICA: United States—Vermont, New Hampshire, Massachusetts, New York, West Virginia (249), Ohio, Indiana, Illinois, Wisconsin, Missouri, Iowa, Washington. Canada —Ontario.

Very distinct among the species of the genus in the long flaccid colored appendages. The nature of the final branching of the apex of the appendages is very hard to see in *M. Russellii*, as in this species, as in many of the genus *Microsphæra*, the appendages are extremely slow in arriving at maturity, and perithecia are frequently found in which the asci and spores are formed, although the appendages are still unbranched. Figs. 38, 39 represent the most branched form of the apex of the appendages that I have seen. Burrill (60) says "appendages simple, bifid, or two or three times irregularly branched, branches long, often distorted, tips not swollen or recurved."

9. M. EUPHORBIAE (Peck) Berk. & Curt.

Erysiphe euphorbiae Peck, Reg. Rep. **26**: 80. 1874; Sacc. Syll. Fung. **1**: 18. 1882.

Microsphaera euphorbiae Berk. & Curt. Grevillea, **4**: 160. 1876; Sacc. Syll. Fung. **1**: 13. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 418. 1887; Atkins Journ. Elisha Mitch. Sci. Soc. **7**: 70. *pl. 1. f. 1–4.* 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 26. 1892.

M. colutea Kom. Scripta Bot. Hort. Univ. Imp. Petropol. **4**: 270. 1895.

EXSICC.: Ell. N. Amer. Fung. 431; Rab.-Wint. Fung. Eur. 3246; Jacz.-Kom.-Tranz. Fung. Ross. Exsicc. 79.

Amphigenous; mycelium usually subpersistent, thin and effused, sometimes evanescent; perithecia often gregarious in floccose patches, but sometimes scattered, 85–145 μ in diameter, rarely reaching to 180 μ, globose-depressed, cells 10–15 μ wide; appendages 7–28, 2½–8 times the diameter of the perithecium, usually narrow (about 5 μ wide), more or less flexuose-contorted angularly bent, and nodulose, but sometimes wider and not angularly bent, always very flexuose, colorless, thin-walled above, becoming thick-walled in the lower half, aseptate, sometimes slightly rough, apex 3–4 times dichotomously branched, branching very irregular and lax, branches strongly flexuose, often more or less curled, lips of ultimate branches straight or recurved; asci

4–13, more rarely 13–26, ovate or ovate-oblong, with a short stalk, 48–66 × 26–35 μ; spores usually 4, sometimes 3, 5 or 6, 19–21 × 10–12 μ.

Hosts.—*Astragalus adsurgens, A. Cooperi, A. Drummondii, A. Mortoni, Colutea arborescens, C. cruenta, Euphorbia corollata, E. hypericifolia, E. marginata* (60) (386), *E. Preslii.*

Distribution.—ASIA: Turkestan.

NORTH AMERICA: United States—New York, North and South Carolina, Michigan, Alabama (12), Illinois, Mississippi, Wisconsin, Missouri (363), Iowa, Kansas, Montana, Colorado.

A very interesting and marked species in the contorted angularly-bent appendages, which occur almost constantly in all examples, and when present, are sufficient, taken in conjunction with the flexuose branching of the apex, to identify the species at once. Where the appendages are not thus characterized, *e. g.*, as in the form on *Colutea* (referred to below), the best distinctive character is found in the very vaguely and widely branched apex of the appendages, the branches of which are irregularly arranged, very flexuose, or variously contorted and twisted.

Up to the present time, *M. euphorbiae* has been considered as occurring only on species of *Euphorbia*, but I have no hesitation in referring to this species American plants occurring on *Astragalus adsurgens, A. Cooperi, A. Drummondii*, and *A. Mortoni.* The fungus on *A. Cooperi* has been recorded by Peck (60) (91) (280) as "*M. holosericea* Lév." [*M. astragali*]; that on *A. adsurgens* I have found labelled "*M. Ravenelii*" in herbaria, and that on *A. Mortoni* named *Erysiphe communis.* All the specimens on the species of *Astragalus* mentioned above have the same peculiarly contorted appendages and irregular branching of the apex as occur in examples of *M. euphorbiae* on species of *Euphorbia.*

Komarov (206) has recently described a species of *Microsphaera*, occurring on *Astragalus* and *Colutea* in Turkestan, under the name of *M. coluteae*, with the following diagnosis: "Bifrons, mycelio arachnoideo, persistente, bene evoluto. Conceptaculis minutis subglobosis. Appendiculae graciles, conceptaculo multo longiores, uncinatae, ramulis ultimis apice turgidis incurvis. Asci 8 subovoidei brevi pedunculati. Sporae in quovis asco 2–6, saepius 3–4. Conidiis cylindrico-ovoideis. Conceptacula ad 90 μ;

appendices 300–400 μ; asci 42–45 × 22–50 μ; sporae 14–22 × 5–14 μ; conidia 28–32 × 10–13 μ."

I have seen the following examples, of this plant: Jacz.-Kom.-Tranz. Fung. Ross. Exsicc. nr. 79, "in fol. vivis *Astragali* sp. Ad. fluv. Seravschan (Turkestan)"; a specimen in the Herbarium of the University of St. Petersburg, from "Darch, 6000 feet. Seravschan" super, "on *Colutea cruenta* Ait."; and a specimen from the same locality as the last, on *Colutea arborescens*, in Professor Tranzschel's herbarium. These two forms on *Colutea* and *Astragalus* are sightly different. On the former host-plant the fungus forms conspicuous floccose patches, due chiefly to the appendages being more assurgent than usual; the perithecia are large, 100–180 μ in diameter, the appendages are 7–28 in number, and very long, reaching sometimes to 8 times the diameter of the perithecium, not angularly bent, nor nodulose, though very flexuose, usually slightly rough for nearly the whole length; the apical branching is very wide—often measuring more than 200 μ wide—and irregular, and the branches are very flexuose and contorted; the asci are 6–23 in number, with 4–5 spores. On *Astragalus* the appendages are intricately contorted and angularly bent, but the branching of the apex is often identical with that of the form on *Colutea*, although the branches are frequently even more flexuose and curled, the ultimate ones being sometimes almost spirally coiled. Good figures of these two forms have been given by Magnus (231. *f. 8–13*).

The characters shown in the branching of the apex, and, in the form on *Astragalus*, in the peculiar contorted appearance of the appendages, certainly in my opinion, refer "*M. coluteae*" to *M. euphorbiae*. I had already, before seeing Komarov's specimens, referred American forms on certain species of *Astragalus* to *M. euphorbiae*, and I now feel convinced that we have this species occurring in North America on *Euphorbia* and *Astragalus*, and in Asia on *Astragalus* and *Colutea*.

I have not seen any examples of *M. euphorbiae* from Europe. Bommer and Rousseau (45) have recorded "*Erysiphe euphorbiae* Peck," in a conidial stage on *Euphorbia amygdaloides* from Belgium; it is quite possible, however, that this fungus may prove to be *Sphaerotheca tomentosa* (*S. mors-uvae*). European specimens in

herbaria, named *E. euphorbiae* Peck" have all proved on examination to be this species of *Sphaerotheca*. Lambotte (209 supp.), however, records a plant from Belgium, which may possibly belong to *M. euphorbiae*. It is recorded as "*Erysiphe euphorbiae* Peck," but the brief description given is not sufficient to identify the plant with certainty; Thèques largement ovées 3–4, spores 3–4, épaisses, 25 × 16; appendices peu longs, flexueux, colorés; périthèces petits; mycelium mince. Feuilles d'Euphorbe."

I follow Burrill in regarding *Microsphaera euphorbiae* Berk. & Curt. as identical with *Erysiphe euphorbiae* Peck; I have not seen an authentic specimen of the latter. Burrill speaking of *M. euphorbiae*, says (60, p. 26) "*Erysiphe euphorbiae* is evidently the same thing. The name seems to have been founded upon specimens in which the appendages were not branched."

10. M. GUARINONII Bri. & Cav. [Figs. 42, 44]

M. Guarinonii Bri. & Cav. Fung. Par. n. 172 (cum diag. et icon.). 1892; and in Hedwigia, **31**: 142. 1892; Cav. in Atl. Istit. Bot. Pavia, II. **3**: 329. 1894; Sacc. Syll. Fung. **11**: 252. 1895.

EXSICC.: Bri. & Cav. Fung. Par. 172.

Amphigenous; mycelium subpersistent, effused; perithecia more or less densely gregarious, 90–126 μ in diameter, globose-depressed, cells large, evident, 12–20 μ wide; appendages 8–20, 8–12 times the diameter of the perithecium, colorless, flexuose, aseptate, smooth, hyaline and thin-walled almost to base, apex 3–4 times dichotomously branched, branching usually lax with the primary branches long, widely spreading, and more or less recurved, sometimes more compact, tips of ultimate branches recurved when mature; asci 4–10, ovate-oblong, with or without a short stalk, 55–68 × 30–38 μ; spores usually 6, sometimes 4 or 5, 20–23 × 10–13 μ.

Host.—*Laburnum vulgare.*

Distribution.—EUROPE: Italy.

A very beautiful species, quite distinct in the very long, flexuose appendages, 3–4 times dichotomously branched, with the tips of the ultimate branches recurved.

Briosi and Cavara show the ultimate branches recurved, but figure the tips of these as straight; this, however, is not the form of the mature apex (see Figs. 42, 44). The asci are described as

8-spored, but in the specimens I have examined no ascus has contained more than 6 spores.

M. Guarinonii has hitherto been recorded from only a single locality in Italy—Varallo, where it was discovered in 1891, and published the next year in Briosi and Cavara's Exsiccati. I have, however, seen specimens from two other Italian localities. One is contained in the Herbarium of the Florence Museum. This specimen was named *Erysiphe Martii*, "on the leaves of *Cytisus Laburnum*, Boscolongo, 1877 (Da Borzi)," with the note attached "appendicibus longissimis hyalinis, ascis ovatis in pedicello productis, 8-sporis." The other specimen was recorded by Massalongo (237, p. 127) as "*M. astragali β cytisi*," from S. Mauro di Saline, Verona, October 5, 1892.

11. M. UMBILICI Kom. [Figs. 45, 46]

M. umbilici Kom. Scripta Bot. Hort. Univ. Petropol. **4**: 270. 1895.

EXSICC.: Jacz.-Kom.-Tranz. Fung. Ross. Exsicc. 29.

Amphigenous; mycelium evanescent; perithecia scattered or gregarious, 90–142 μ in diameter, cells 10–15 μ wide; appendages 4–10, 1–1¾ times the diameter of the perithecium, not flaccid, aseptate and colorless, or brownish at base and 1–3-septate, apex (? mature) 4–5 times dichotomously branched, branching rather close, branches of the higher orders more or less irregularly placed, tips of the ultimate branches not recurved; asci 4–14, ovate-oblong, shortly stalked, 58–70 × 23–38 μ; spores 3–5, 22–25 × 10–13 μ.

"Mycelio arachnoideo persistente, matricis superficiem totam occupante. Peritheciis minutis subglobosis. Appendiculae peritheciis aequantes rectae breves ad basin leniter coloratae, ramulis ultimis apice turgidis. Ascis in quovis perithecio 5–8, ovoideis vel ellipsoideis brevipedunculatis; sporis 3–2 cylindrico ovoideis. Conidiis cylindricis utrinque rotundatis. Peritheciis 90–120 μ; appendiculis 90–130; ascis 40–54 × 30–45; sporis 16–22 × 8–12; conidiis 25–32 × 8–12" (Kom. *loc. cit.*).

Host.—*Cotyledon Semenovii* (= *Umbilicus Semenovii*).

Distribution.—ASIA: Turkestan (Seravschan).

I have not seen sufficiently mature examples of this plant to be able to express an opinion as to its position. The only specimens examined (from which my description was drawn up) have been those

in the exsiccati quoted. These specimens, although many perithecia contain asci and spores, are too immature to show with certainty the form of the mature apex of the appendages. The most developed stage in the branching of the apex that I have seen is shown at Fig. 45. It is, however, possible that this does not represent the final form, and the somewhat swollen tips of many of the branches rather favors the view that further division takes place. It is frequently the case in species of *Microsphaera* that the asci and spores are developed long before the apical branching of the appendages has attained its mature form.

12. M. FERRUGINEA Erikss. [Figs. 56–58]

M. ferruginea Erikss. Fung par. scand. n. 145 (cum diag.) 1883; Erikss. Bidr. Känned. vara odl. växt. sjuk. 46. 1885.

EXSICC. *Erikss. Fung. par. scand. 145.

Amphigenous; mycelium subpersistent; perithecia scattered, 70–100 μ in diameter, cells small, rather regular, 10–12 μ wide; appendages 4–7, rarely 7–10, about 1½ times the diameter of the perithecium, colorless, smoth, thin-walled above, becoming thick-walled below, apex 3–4 times dichotomously branched, branching rather vague and lax, tips of the ultimate branches not recurved; asci 4–6, ovate-oblong, with or without a short stalk, 45–52 × 26–30 μ; spores 4–?, 20 × 13 μ.

"Caespites amphigeni, ferruginei, pulveracei, demum late effusi et confluentes. Conidia utrinque rotundata, pallide fusca, pellucida, 28–32 μ longa, 16–18 μ lata. Perithecia fusco-atra, sparsa, mycelio densissimo arachnoideo persistente intexta, 80–90 μ in diam. Appendices 6–10, perithecium aequantes vel duplo longiores, 4–6: eis dichotomae, hyalinae. Asci 6–8 in quoque perithecio, 44–50 μ longi, 26–30 μ lati. Sporae 6–8 in quoque asco, 16–18 μ longae, 10–12 μ latae. (Erikss. *loc. cit.*)

Host.—*Verbena hybrida* (cult.).

Distribution.—EUROPE: Sweden.

The specimen which Professor Eriksson kindly sent to me for examination from his herbarium, and that in the Exsiccati quoted, are unfortunately both immature. Only a very few perithecia are sufficiently mature to show any apical branching at all of the appendages. Figs. 56 and 57 show the apex of the most developed appendages seen, but it is very possible that the form here represented is not that of the fully mature apex. It would be hardly

wise, therefore, to express any opinion as to the position of the species.

Eriksson (119) gives the following account of the damage caused by *M. ferruginea* to cultivated plants of *Verbena hybrida*. "So sind seit mehreren Jahren zu Rosendal alle Freilandgruppen von *Verbena hybrida* stark mehlthaukrank gewesen. Dieser Mehlthau sucht aufangs hauptsächlich die Unterseite der Blätter heim, die ein bleichrostfarbiges Aussehen mit hier und da eingestreuten Staubgruppen von derselben Farbe bekommen, bis endlich das Blatt ganz eingesponnen ist. Die Pflanze hat jetzt eben so wie andere mehlthaukranke Pflanzen ein mehr oder weinger weisses Aussehen ausgenommen. . . . Da die Krankheit trotz reichlichem Schwefeln fortdauert, so hat man sich schliesslich genöthigt gefunden, mit der Cultur der Verbenen, wenigstens der älteren, durch Stecklinge vermehrten Varietäten fast gänzlich aufzuhören . . . Bei Rosendal hat man in den letzten Jahren aus Samen, die un Frühjahre ausgesäet waren, kräftigere und dem Mehlthaue weinger ausgesetzte Exemplare gezogen."

13. M. BÄUMLERI P. Magn. [Figs. 52–55]

P. Bäumleri P. Magn. Bericht. Deutsch. Botan. Gesell. **17**: 148. *pl. 9. f. 17–18.* 1899.

M. Marchica P. Magn. Bericht. Deutsch. Botan. Gesell. **17**: 149. *pl. 9. f. 19.* 1899.

EXSICC.: Rehm. Ascom. 249 sub *Erysiphe Martii.*

Hypophyllous (very rarely amphigenous); mycelium subpersistent or evanescent; perithecia more or less densely gregarious in floccose patches covering the surface of the leaf, globose-depressed, becoming hemispherical, 80–150 μ in diameter; appendages 8–20, usually 8–14, 4–6 times the diameter of the perithecium, flaccid, penicillate when mature, smooth or slightly rough, colorless, thick-walled at base, apex about 3 times dichotomously branched when mature, branching vague and lax, branches of the higher orders more or less irregularly placed, tips of the ultimate branches not recurved; asci 4–12, ovate to oblong, usually shortly stalked, 55–70 × 30–38 μ; spores 4–6 (8 recorded by Magnus), 20–22 × 10–12 μ.

Hosts.—*Vicia cassubica, V. sylvatica.*

Distribution.—EUROPE: Britain (Scotland), Italy, Austria-Hungary, Germany, Russia.

When working through the material of the Erysiphaceae in the Kew Herbarium at the end of last year, I noticed certain specimens named "*Erysiphe communis*" in Berkeley's herbarium (on *Vicia sylvatica*, from Scotland), and others named "*E. Martii*," in Rehm's Ascomyc., n. 249 (on *V. cassubica*, from Franken), which clearly belonged to the genus *Microsphaera*. This was also the case with specimens sent as "*E. Martii*," about the same time, by Professor Massalongo from Italy, and with Russian specimens, named "*E. astragali?*" in Professor Tranzschel's Russian herbarium—both on *V. sylvatica*.

These specimens showed the apex of the appendages about three times dichotomously branched, with the branching vague and irregular. A very slow development of the apical branching was evidently characteristic of the plant, and the appendages in this and other characters closely resembled those of *M. astragali*, to which species I had intended referring the plant as a new variety, differing from the type in the more branched apex of the appendages.

Magnus (231) has since described the plant on *Vicia sylvatica*, (from Hungary), as a new species, *Microsphaera Bäumleri*, and has at the same time published another species, *M. Marchica*, on *V. cassubica*.

M. Bäumleri is described as follows: "Sie hat schöne lange Appendiculae, die an den Enden ein bis vier Mal dichotom getheilt sind. Die letzten Verzweigungen der Appendiculae sind stets ziemlich lang und stets gerade vorgestreckt, vorne stumpf abgerundet ohne jede Spur einer Krümmung. . . Sie ist durch die ziemlich langen, wenig divergirenden, gerade vorgestreckten, vorn stumpf abgerundeten Enden der letzten Gabelungen der Appendiculae vor den anderen in der alten Welt auf Papilionaceen auftretenden Microsphaeren recht ausgezeichnet. Auch bei ihr kommen zuweilen unverzweigte Appendiculae vor. Der Durchmesser der Perithecien is durchschnittlich 120 μ. Der Ascus enthält meist 8 Sporen. Die Ascosporen sind 18 μ lang und 10 μ breit. Sie schliesst sich der *M. diffusa* C. et P. an."

M. marchica is thus described: "Die Perithecien sind 110–130 μ breit. . . . Die Appendiculae entspringen von der oberen Hälfte des kugeligen Apotheciums und richten sich meist

schopfartig auf, wie bei *M. astragali.* Sie sind meist einfach, nur selten an der Spitze zweitheilig oder zweimal zweitheilig. Sie sind etwa vier—bis sechsmal so lang als das Perithecium. . . . Die Appendiculae sind an den Enden breit abgerundet stumpf. . . . Auch schliesst sie sich verwandtschaftlich der *M. coluteae* Kom. und *M. Bäumleri* P. Magn. nahe an."

Professor Magnus has very kindly sent me specimens (now in the Kew Herbarium) of *M. Mäumleri* and *M. Barchica. M. Bäumleri* shows the characters as given in my description above.

M. Marchica I consider is founded on an immature stage of the same species. In Magnus' figure (231, *f. 19*) the appendages are represented as unbranched, and in the diagnosis are said to be " meist einfach, nur selten an der Spitze zweitheilig oder zweimal zweitheilig." The specimens sent by Professor Magnus (which agree with the description given) are certainly too immature to show the nature of the final branching of the apex. The appendages in these specimens are either undivided at the apex, or have begun to fork once or twice. The specimens on the same host (*Vicia cassubica*) in Rehm's Ascomyc. n. 249, which certainly represents the same plant, is much more mature, and the appendages here show so close a resemblance in their branching to that of *M. Bäumleri*, and the habit of the two plants are so similar, that I feel bound to consider them as belonging to one species.

The other plant on *Vicia sylvatica* mentioned by Professor Magnus (231, p. 148), of which specimens were sent, I consider also to be *M. Bäumleri* in an immature condition.

The affinity of *M. Bäumleri* is certainly with *M. astragali. M. diffusa*, to which the present species has been compared, differs widely in the shorter, non-penicillate appendages, more branched apex of the appendages, etc. In *M. astragali* the appendages are usually unbranched, sometimes once forked, or rarely twice dichotomous. I have once, however, seen a specimen in which the apex showed signs of becoming 3 times dichotomously branched. (Fig. 47). How far the usually unbranched condition of the appendages of *M. astragali* is to be considered as the result merely of immaturity, remains at present doubtful; it is possible that further investigations of fully mature specimens may prove that the apex becomes branched regularly in age, and even that *M. Bäumleri* should be united with *M. astragali.*

M. cuonymi, also, is related to the present species in the penicillate (though usually shorter) appendages, but differs in the closer and more elaborate branching of the appendages.

M. Bäumleri has hitherto been recorded only from Germany and Austria, but specimens from the following countries belong here: Scotland, New Pitsligo (specimen in Herb. Berkeley at Kew); Italy, Verona (Massalongo, Sept., 1887); Russia, Bologov, prov. Novgorod (Tranzschel, Aug., 1897).

ERYSIPHE Hedw. f.; DC. (emend. Lév.) Ann. sci. nat. III. **15**: 161. 1851

Perithecia globose, or globose-depressed, sometimes becoming concave; asci several, 2–8-spored. Appendages floccose, simple or irregularly branched (never with a definite apical branching), sometimes obsolete, usually more or less similar to the mycelium and interwoven with it, very rarely (*E. tortilis*) brown, assurgent and fasciculate. Etym. ερυσιβη, *robigo*.

Distribution.—Europe, Africa, Asia, Australia, New Zealand, North America—8 species and 1 variety.

The genus is characterized by the floccose appendages (sometimes obsolete or apparently absent), simple or vaguely branched, more or less similar to the hyphae of the mycelium, and frequently interwoven with them. *Sphaerotheca* is distinguished by the single ascus. *E. tortilis* has a habit approaching that of some species of *Microsphaera*—a genus connected on its side with *Erysiphe* through *M. astragali*.

Key to the Species of Erysiphe

1. Asci (of mature perithecia) not containing spores on the living host-plant. 2.
   Asci (of mature perithecia) containing spores. 4
2. Perithecia large, 135–280 μ in diameter, averaging 200 μ, more or less immersed in the lanuginose persistent mycelium. 4. *graminis*.
   Perithecia smaller, 80–140 μ, not immersed in a lanuginose mycelium. 3.
3. Haustoria lobed. 3. *galeopsidis*.
   Haustoria not lobed. 2. *cichoraccarum*.
4. Asci 2-spored, rarely (and never uniformly) 3-spored. 5.
   Asci 3–8-spored, rarely (and never uniformly) 2-spored. 8.
5. Perithecia 52–60 μ in diam.; asci 3, 48–50 $\times$ 28–36 μ. 8. *trina*.
   Perithecia 80–240 μ in diam.; asci more than 3, larger. 6.
6. Perithecia large, becoming pezizoid, 135–240 μ in diameter, usually about 200 μ; asci 7–38, usually about 20, 75–110 μ long, averaging 90 μ, spores 28–40 μ long, averaging 32 $\times$ 18 μ long. 6. *taurica*.

Perithecia 80–140 μ (very rarely 100–175); asci 4–25 (very rarely as many as 36). usually 10–15, 58–90 μ long; spores 20–28 μ long, averaging 34 × 14 μ. 7.

7. Haustoria lobed. 3. *galeopsidis*.
Haustoria not lobed. 2. *cichoracearum*.

8. Perithecia 65–180 μ in diameter, usually about 90 μ; asci usually few, 2–8, rarely as many as 22, 46–72 (rarely 80) μ long. 9.
Perithecia larger, 130–280 μ in diameter, averaging 180–200 μ; asci 9–42, 70–115 μ long. 10.

9. Appendages very long, 10–20 times the diameter of the perithecium, assurgent and fasciculate. 5. *tortilis*.
Appendages long or short, spreading horizontally, often interwoven with the mycelium. 1. *polygoni*.

10. Perithecia more or less immersed in the lanuginose persistent mycelium. 4. *graminis*.
Perithecia not immersed in a lanuginose persistent mycelium. 11.

11. Spores 4–6, 20–22 × 10–12 μ. 1. *polygoni*, var. *sepulta*.
Spores 8, rarely 6 or 7, somewhat roundish, 16–20 × 10–15 μ. 7. *aggregata*.

1. ERYSIPHE POLYGONI DC. [Figs. 132–139, 143, 155, 158]

Mucor Erysiphe Linn. Syst. Veg. 825 (partim). 1774.

Sclerotium Erysiphe Pers. Obs. Myc. 1 : 13 (partim). 1796; Pers. Syn. Meth. Fung. 124 (partim). 1801.

S. Erysiphe, var. *herbarum* Alb. & Schwein. Consp. Fung. Lusat. 76. 1805.

Erysiphe polygoni DC. Fl. Fr. 2 : 273. 1805.

E. convolvuli DC. Fl. Fr. 2 : 274. 1805.

E. pisi DC. Fl. Fr. 2 : 274. 1805; Grev. Scot. Crypt. Fl. 3 : *pl. 134*. 1825.

E. heraclei DC. Syn. Pl. Fl. Gall. 57. 1806.

E. aquilegiae DC. Fl. Fr. 6 : 105. 1815.

E. scandicis DC. Fl. Fr. 6 : 107. 1815.

E. varium Fr. Obs. Myc. 1 : 206 (partim). 1815; and 2 : 366. 1818.

Erysibe pycnopus Mart. Fl. Crypt. Erlang. 329. 1817.

E. macropus Mart. Fl. Crypt. Erlang. 329. 1817.

Alphitomorpha communis Wallr. Berl. Ges. Nat. Freund. Verh. 1 : 31 (excl. vars. *graminearum*, *labiatarum*, *cichoracearum*). 1819; Wallr. Fl. Crypt. Germ. 2 : 758 (partim). 1833.

A. urticae Wallr. Ann. Wett. Ges. 4 : 238. 1819.

A. trifoliorum Wallr. Ann. Wett. Ges. 4 : 238. 1819.

A. hyperici Wallr. Ann. Wett. Ges. 4 : 239. 1819.

A. heraclei Wallr. Ann. Wett. Ges. **4**: 240. 1819.

A. pisi Wallr. Ann. Wett. Ges. **4**: 241. 1819.

Erysibe polygoni DC.; Gray, Nat. Arr. Brit. Pl. **1**: 589. 1821; Schroet. Cohn's Krypt. Fl. Schles. **3**: 234. 1893.

E. pisi DC.; Gray, Nat. Arr. Brit. Pl. **1**: 589. 1821; Schroet. Cohn's Krypt. Fl. Schles. **3**: 236. 1893.

E. convolvuli DC.; Gray, Nat. Arr. Brit. Pl. **1**: 589. 1821.

Erysibe communis Fic. & Schub. Fl. Gegend. Dresd. **2**: 304. 1823; Lk. Willd. Sp. Pl. **6**: 105 (excl. vars. *graminum, labiatarum, cichoracearum*). 1824; Rabenh. Deutschl. Crypt. Fl. **1**: 232 (partim). 1844.

Erysiphe trifolii Grev. Fl. Edin. 459. 1824.

E. lathyri Grev. Fl. Edin. 460. 1824.

E. robiniae Grev. Fl. Edin. 460. 1824.

E. asperifoliorum Grev. Fl. Edin. 461 (partim). 1824.

E. ranunculi Grev. Fl. Edin. 461. 1824.

[?] *Erysibe epimischa* (*Physalis*) Lk.; Willd. Sp. Pl. **6**: 110. 1824.

Erysiphe communis Grev. Scot. Crypt. Fl. Synops. 9. 1828; Fr. Syst. Myc. **3**: 239 (partim). 1829; Duby, Bot. Gall. **2**: 869 (excl. vars. *graminum, labiatarum, cichoracearum*. 1830; Berk.; Sm. Engl. Fl. 5, pt. 2, 325 (partim). 1836; Dur. & Mont. Fl. d'Algér. (Crypt.) 565 (excl. var *graminis*). 1846–9; Lév. Ann. sci. nat. **15**: 171. *pl. 11. f. 38.* 1851; Tul. Sel. Fung. Carp. **1**: 214. 1861; Cooke, Micr. Fung, 221. *pl. 12. f. 240–242.* 1865; de Bary, Beitr. Morph. Phys. Pilz. **1**: §xiii. 50. 1870; Cooke, Handb. Brit. Fung. **2**: 652. 1871; Karst. Myc. Fenn. 194. 1873; Sacc. Syll. Fung. **1**: 18. 1882; Witn.; Rabenh. Krypt. Fl. Deutschl. **1²**: 32. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 93. 1885; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 402. 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. **7**: 64. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 10. 1892; Jacz. Bull. l'Herb. Boiss. **4**: 731. 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 97. 1897.

Perisporium erysiphoides Fr. Syst. Myc. **3**: 251. 1829.

Erysiphe daphnes Duby, Bot. Gall. **2**: 870. 1830.

Alphitomorpha nitida Wallr. Fl. Crypt. Germ. **2**: 757. 1833.

Erysiphe liriodendri Schwein. Syn. Fung. Am. Bor. 269.

1834; Sacc. Syll. Fung. **1**: 21. 1882; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 401. 1887; Burr.; Ell. & Everh. N. Amer. Pyren. 10. 1892.

Erysiphe macularis Kickx. Fl. Crypt. Env. Louv. 138 (partim). 1835.

E. Perisporium Cord. Icon. Fung. **2**: 28. *pl. 13. f. 99.* 1838.

Erysibe nitida (*delphinii*) Rabenh. Deutschl. Krypt. Fl. **1**: 231. 1844.

Erysiphe convolvuli sepii Cast. Cat. Pl. Mars. 188. 1845.

E. ranunculi Cast. Cat. Pl. Mars. 189. 1845.

E. polygoni Cast. Cat. Pl. Mars. 189. 1845.

Erysibe ulmariae Desmaz. Ann. sci. nat. III. **6**: 66. 1846; Desmaz. Fl. Crypt. Fr. ser. 1, n. 1515. 1846; *Desmaz. Mém. Soc. Roy. Sci. Lille for 1846: 141. 1847; Desmaz. Ann. sci. nat. II. **8**: 14. 1847.

Erysiphe Martii Lév. Ann. sci. nat. III. **15**: 166. *pl. 10. f. 34* (syn. excl. partim). 1851; Cooke, Micr. Fung. 220. *pl. 11. f. 237–239.* 1865; Cooke, Handb. Brit. Fung. **2**: 651. 1871; Karst. Myc. Fenn. **2**: 193. 1873; Sacc. Syll. Fung. **1**: 19. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 31. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 93. 1885; Jacz. Bull. l'Herb. Boiss. **4**: 728. 1896. Oudem. Rév. Champ. Pay.-Bas. **2**: 97. 1897.

E. densa Berk. Hook. Fl. Nov. Zeal. **2**: 208. *pl. 105. f. 16.* 1855; Hook. Handb. New Zeal. Fl. 637. 1867; Sacc. Syll. Fung. **1**: 18. 1882.

E. ulmariae Desmaz.; Kickx. Fl. Crypt. Fland. **1**: 381. 1867; Sacc. Syll. Fung. **1**: 19. 1882; Oudem. Rév. Champ. Pays.-Bas. **2**: 99. 1897.

E. umbelliferarum de Bary, Beitr. Morph. Phys. Pilz. **1**: § xiii. 50. 1870; Sacc. Syll. Fung. **1**: 17. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**^{2}: 31. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 93. 1885; Oudem. Rév. Champ. Pays.-Bas. **2**: 96. 1897.

E. vernalis Karst. Myc. Fenn. **2**: 193. 1873; Karst. Helsing. Faun. Fl. Fenn. Notis. **13**: 247. 1874; Sacc. Syll. Fung. **1**: 19. 1882; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 93. 1885.

E. Martii Lév. f. *acaciae* Erikss. Bid. Känned. våra odlade växt. sjuk. 51. 1885.

Erysibe heraclei DC.; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 239. 1893.

Erysiphe communis, var. *umbellifcrarum* (de Bary) Jacz. Bull. l'Herb. Boiss. **4**: 733. 1896; Jacz.-Kom.-Tranz. Fung. Ross. Exsicc. no. 130 (cum diag.). 1896.

E. communis, var. *ulmariae* Jacz. Bull. l'Herb. Boiss. **4**: 734. 1896.

Microsphaera caraganae Magn. Bericht. Deutsch. Bot. Gesellsch. **17**: 150. *pl. 9. f. 1–4.* 1899.

Erysiphopsis parnassiae Halsted, Bull. Torr. Club, **26**: 594. 1899.

EXSICC.: Bri. e Cav. Fung. par. 173; Rab. Fung. Eur. 31, 562, 563, 564, 1057, 1060, 1061, 1062, 1063, 1064, 1065, 1068, 1069, 1426, 1431, 1522, 1736, 1918, 2027, 2134, 2415, 2521; Syd. Myc. March. 198, 338, 653, 659, 838, 839, 980, 981, 1077, 1142, 1143, 1198, 1240, 1638, 2222, 2328, 2658, 2659, 2765, *3669, *3671, *3718, *3822, *3914, *3915, *3916, *3917, *4241, and 432, 655, 1541, 1640, 3052 sub *Sphaerotheca Castagnei;* Fckl. Fung. Rhen. 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 671, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 1738, 1742, 1743, 1744, 2237 and 432, 1541, 3052, sub *Sphaerotheca Castagnei;* Rab. Herb. Myc. ed. 2, 462, 466, 467, *476, 477, 479, *480, 482, 483, *486, 670; Roumeg. Fung. Gall. Exsicc. 1376, 1379, 1534, 1539, 1983, 2072, 2074, 2373, 2450, 2556, 2557, 3226, 3646, 3741, 4565, and 3645, sub *E. lamprocarpa;* Desmaz. Pl. Crypt. Fr. ser. 1, 166, 264, 265, 459, 1108, 1304 (B only), 1515, 1518, 2197, 2198; ser. 2, 671, 672; *ed. 2, ser. 1, 109, 508 (A only), 813, 1015, 1018, 1847, 1848; Jacz.-Kom.-Tranz. Fung. Ross. Exsicc. 130; de Thuem. Fung. exot. dec. 12, sub *E. lamprocarpa;* de Thuem. Fung. austr. 143, 144, 145, 146, 239, 240, 241, 447, 448, 449, 453, 454, 455, 458, 651, 652, 857, 955, *1044, 1141, 1143, 1240, 1241, 1242, 1243 and 457 sub *E. horridula;* and 1237 sub *Microsphaera astragali;* Sacc. Myc. Ven. 68, 149, 150, 151, 602, 603, 604, 605, 609, 610, 695, 786, 787, 896, 897, 898, 1170; Rehm. Ascom. 350, 398, 399, 449, 500, 546, 547, 650, 799, 800; Fries, Scleromyc. Suaec. 69; Cooke, Fung. Brit. Exsicc. 96, 99; ed. 2, 288, 593, 594, 600; Vize. Fung. Brit. 95, 98; Westend. Herb. Crypt. Belg. 120, 408, 553 (e only), 737, 830, 1389; de Thuem. Myc. univ. 156, *449, 1449, 1937, 2057; Karst.

Fung. Fenn. Exsicc. 280, 368, 784; *Wartm. & Schenk, Schweiz. Krypt. 524, 525, 629; Wahrlich. Parasit. Pilz. 28, 29 (in Herb. Hort. Imp. Petropol.); *Funck, Crypt. Gew. Fichtelgeb. 384; *Erikss. Fung. par. scand. 38a, 38b, 148a, 236, 237, 340; *Schmidt & Kunz. Deutschl. Schw. ccxxii.; Seym. & Earle, Econ. Fung. 252; *Kneiff. & Hartm. Fl. Crypt. Bad. 159; *Krieg. Fung. Saxon. 71, 822, 823, 824, 825, 827, 828, 829, 830, 831; *Gandog. Fl. Alger. exsicc. 1980, 1983; *Ell. & Everh. Fung. Columb. 614; *Cav. Fung. Long. exsicc. 118; Oudem. Fung. Neerl. Exsicc. 73, 74, 155, 156, 157, 158; Zopf & Syd. Myc. March. 52; Jack, Lein. & Stizenb. Krypt. Bad. 631, 632; Speg. Dec. Myc. Ital. 84, 84bis; Klotzsch, Herb. Myc. 61; and 65 sub *E. urticae;* and 1743, 1744 (Herb. Mus. Florence); Berk. Brit. Fung. 200, 201, 203, 269; Baxt. Stirp. Crypt. Oxon. fasc. 2, 97; Rab.-Wint. Fung. Eur. 3243; Kunze, Fung. select. exsicc. 60; Erbar. Critt. Ital. ser. 1, 192 (in Herb. Mus. Florence); Linhart, Fung. hungar. 457 (in Iowa State College Herb.); Ell. & Everh. N. Amer. Fung. 835, 2112, sec. ser. 3103.

Amphigenous; mycelium very variable, persistent, thin, effused and arachnoid or rarely thick, dense and lichenoid, or more often completely evanescent; perithecia gregarious to scattered, rarely densely gregarious, usually rather small, about 90 μ, but varying from 65–180 μ in diameter, cells usually distinct, 10–15 μ wide, rarely 20 μ wide; appendages very variable in number and length, sometimes few (3–7), distinct and long (10 times or more the diameter of the perithecium), or more rarely few and short, usually numerous and crowded, more or less densely interwoven, and long or short, always spreading horizontally, often interwoven with the mycelium, simple or rarely much branched, and then widely and irregularly forking, sometimes angularly bent, or flexuose-contorted, colored dark or pale brown at the base or throughout, or quite colorless, rarely becoming shining white, septate when colored; asci usually few, 2–8, rarely as many as 22, variable in shape and size, usually small and ovate, but varying from ovate to broadly ovate or subglobose, with or without a short stalk, 46–72 (very rarely reaching to 80 μ) × 30–45 μ; spores 3–8, usually 3–6, very rarely (and never uniformly), only 2, 19–25 × 9–14 μ.

Hosts.—Achillea Ptarmica (350), *Aconitum Anthora* (341), *A. Fischeri, A. Napellus, A. paniculatum* (176), *Actaea spicata, Adonis vernalis* (22), *Aegopodium Podograria* (176) (230) (390), *Aethusa Cynapium, Ajuga reptans* (353), *Albizzia lophantha, Alnus incana,*

Alyssum calycinum, *A. campestre* (272), *Amelanchier alnifolia* (200), *A. maculatum* (6), *Amphicarpaea Edgeworthii*, var. *Japonica*, *A. monoica*, *Anchusa officinalis*, *Anemone dichotoma*, *A. ranunculoides* (108), *A. thalictroides* (280), *A. Virginiana*, *Angelica sylvestris*, *Anthriscus Cerefolium*, *A. sylvestris*, *Antirrhinum Orontium* (230), *Aquilegia Canadensis*, *A. vulgaris*, *Arabis Turrita* (230), *Archangelica officinalis*, *Arenaria decipiens*, *A. juniperina* (389), *Aristotelia racemosa*, *Asperula odorata* (3), *Aster commutatus* (119), *Astragalus adsurgens*, *A. baeticus*, *A. caespitosus*, *A. Canadensis*, *A. caryocarpus* (60), *A. decumbens* (6), *A. frigidus*, var. *Americanus*, *A. Gebleri*, *A. glycyphyllosus* (359) (390), *A. hypoglottis* (6), *A. junceus* (363), *A. Lamberti*, *A. multiflorus* (6), *A. oroboides* and var. *Americanus*, *A. reflexistipulus*, *A. triphyllus* (7) (60), *A. virgatus*, *Baptisia tinctoria*, *Brassica Rapa*, *B. Sinapistrum* (56) (271), *B. sinapoides* (214), *Breynia acuminata*, *Calendula arvensis* (55), *C. officinalis* (22) (209), *Caltha palustris*, *Calystegia sepium*, *Campanula rapunculoides*, *Capsella Bursa-pastoris*, *Caragana arborescens*, *Carduus* sp., *Carum Persicum* (233), *Cassia Chamaecrista* (361), *Catalpa syringaefolia*, *Caucalis Japonica*, *Centaurea scabiosa* (364), *Chaerophyllum aromaticum*, *C. aureum*, *C. bulbosum* (345) (383), *C. hirsutum*, *C. nodosum* (383), *C. temulum*, *C. Villarsii* (230), *Chelone glabra* (122), *Cicuta virosa* (319), *Cimicifuga foetida* (347), *Circaea Lutetiana*, *Clematis alpina*, and var. *Sibirica* (341), *C. Flammula* (cult.), *C. fusca*, var. *yezoëusis*, *C. integrifolia* (319), *C. leucantha* (319), *C. ligusticifolia* (363), *C. recta*, *C. Virginiana*, *C. Vitalba*, *Cnicus lanceolatus*, *Colutea arborescens*, *Conium maculatum* (285) (319), *Convolvulus Ammannii*, *C. arvensis*, *C. sagittatus*, *Coronilla Emerus* (285), *C. varia* (230), *Crambe Scwerzowi* (206), *Cucumis sativus* (230), *Cucurbita* (39), *C. Pepo* (230) (319), *Cuphea viscosissima*, *Cytisus purpureus* (378), *Dahlia* (cult.) (363), *Daphne alpina*, *Daucus grandiflorus*, *Delphinium Ajacis*, *D. azureum* (263), *D. Consolida*, *D. elatum*, *D. formosum*, *D. grandiflorum* (288), *D. orientale*, *D. tiroliense* (230), *D. vestitum*, *Desmanthus brachylobus* (cult.), *Diervilla Japonica*, *Diplotaxis tenuifolia* (214), *Dipsacus laciniata*, *D. sylvestris* (56) (133) (319), *Draba hirta* (60), *Echium vulgare*, *Elsholtzia cristata*, *Erectites praealta* (35), *Eryngium macrocalyx*, *Erysimum cheiranthoides* (107), *E. odoratum* (353), *Fagopyrum esculentum*, *Falcaria vulgaris*, *Falcata comosa* (386),

Galium (35) (394), *G. Aparine* (3) (56) (107) (133) (205*) (230) (263) (290) (319), *G. boreale* (206) (359), *G. Mollugo* (133), *G. sylvaticum* (3) (205*) (290) (391), *Geranium dissectum* (3), *G. maculatum*, *G. molle* (263), *G. pratense* (107) (132) (133) (345), *G. pusillum* (345), *G. pyrenaicum* (214), *G. Richardsoni* (60) (199), *G. sylvaticum* (290), *G. tuberosum* (206), *Geum urbanum*, *Gutierrezia Euthamiae* (199), *Gypsophila Gmelini*, *Heracleum asperum* (cult.), *H. flavescens* (345), *H. palmatum*, *H. Sibiricum*, *H. Sphondylium*, *Hesperis matronalis*, *H. tristis* (22), *Heuchera Americana* (157*), *Hosackia parviflora*, *Hyoscyamus niger* (347), *Hypericum atomarium*, *H. hirsutum*, *H. montanum*, *H. perforatum*, *H. quadrangulum*, *Inula salicina* (22) (348), *Isatis tinctoria* (50), *Johrenia* sp., *Lactuca muralis* (3), *Lithospermum arvense* (3), *Lathyrus Aphaca*, *L. montanus* (115) (133) (311), *L. Nessolia* (263), *L. pisiformis*, *L. polymorphus* (363), *L. polyphyllus*, *L. pratensis*, *L. tuberosus*, *L. uliginosus*, *L. venosus*, *Lespedeza striata* (151), *Linaria genistifolia* (22), *Liriodendron Tulipifera*, *Lotus corniculatus* (383 and 384), *L. major*, *L. Purshiana*, *Lunaria rediviva* (290), *Lupinus albus*, *L. angustifolius* (319), *L. argenteus* var. *argophyllus* (363), *L. laxiflorus*, *L. luteus*, *L. parviflorus*, *L. perennis*, *L. sericeus*, *Lychnis alba* (319) (344), *L. dioica*, *L. sylvestris* (22), *Lycopersicum esculentum* (342), *Lycopsis arvensis*, *Lythrum Salicaria*, *Malcomia maritima* (56), *Medicago falcata*, *M. lupulina*, *M. sativa*, *Melilotus alba*, *M. officinalis*, *Myrrhis odorata*, *Oenothera albicaulis*, *O. biennis*, *O. sinuata* (12) (60), *Onobrychis viciaefolia* (22) (56) (230) (290), *Ononis arvensis*, *O. hircina* (319), *O. spinosa*, *Orobus Lathyroides*, *Oxytropis Lamberti*, *Paeonia obovata*, *P. officinalis*, *P. peregrina*, *Parnassia Caroliniana*, *Pedicularis resupinata* (309), *Peucedanum alsaticum* (22), *P. Cervaria* (22) (377), *P. oreoselinum*, *P. sativum*, *P. terebinthaceum*, *Phaseolus helvolus* (363), *P. perennis* (60), *Phloiodocarpus dahuricus*, *Physospermum commutatum*, *Picris hieracioides* (347), *Pilea stipulosa*, *Pimpinella magna*, *P. Saxifraga*, *Pisum sativum*, *Polygonum aviculare*, *P. dumetorum*, *P. lapathifolium*, *P. Persicaria* (66), *P. ramosissimum*, and var. *prolificum* (151), *Potentilla* (176), *Prenanthes purpurea* (133) (290), *Psoralea tenuiflora* (60) (151), *Quercus glauca*, *Ranunculus abortivus*, *R. aconitifolius* (290) (319) (364), *R. acris*, *R. arvensis*, *R. Asiaticus* (354), *R. bulbosus*, *R. Cymbalaria*, *R. Flammula*, *R. lanuginosus*

(176) (319), *R. Lingua* (318), *R. macranthus* (6), *R. montanus*, *R. multifidus*, *R. Pennsylvanicus*, *R. repens*, *R. sardous*, *R. sceleratus* (6) (199), *R. septentrionalis* (60), *R. trachycarpus*, *Robinia Pseudacacia* (95) (319), *R. viscosa*, *Rumex Acetosella*, *R. Hydrolapathum* (318), *Saxifraga cortusaefolia*, *Scabiosa arvensis*, *S. stellata* (50), *S. Succisa* (107), *S. sylvatica*, *Scandix Pecten-Veneris*, *Scutellaria lateriflora* (35) (386), *S. scordiifolia*, *Selinum carvifolia*, *Sselie* (349), *S. Libanotis* (164*), *Silaus flavescens* (319), *Silene noctiflora* (22), *Siler trilobum* (391), *Sisymbrium alliaria* (22), *S. officinale* (56), *S. Sophia*, *Sium erectum*, *S. latifolium* (319), *Smyrnium olusatrum* (18), *Sonchus* (172), *S. arvensis* (22), *Spartium junceum* (272), *Spiraea ulmaria*, *Statice Gmelini*, *S. Limonium*, *Symphytum officinale* (3), *Teucrium Chamaedrys* (20), *Thalictrum angustifolium* (319), *T. aquilegifolium*, *T. Cornuti*, *T. flavum*, *T. minus* and var. *elatum*, *T. simplex*, *Thermopsis montana*, *Thesium Bavaricum* (378), *T. ebracteatum* (107), *Thlaspi arvense* (310), *Tragopogon* (301), *Trifolium agrarium* (290) (319) (384), *T. alpestre*, *T. arvense*, *T. filiforme*, *T. hybridum*, *T. incarnatum*, *T. involucratum*, *T. longipes*, *T. Lupinaster*, *T. medium*, *T. minus*, *T. monanthum* (60), *T. montanum*, *T. moranthum*, *T. pauciflorum*, *T. pratense*, *T. procumbens*, *T. repens* (18) (290) (319), *T. rubens*, *Trigonella cretica*, *T. Foenum-graecum*, *Trollius Europaeus*, *Urtica cannabina*, *U. dioica*, *U. urens* (263), *Valeriana capitata* (206), *V. officinalis* (22) (107) (132) (133) (192) (230) (319), *Valerianella dentata* (319), *V. rimosa* (73*), *Verbascum phlomoides* (302), *V. Thapsus* (107) (263), *Verbena urticifolia* (35), *Veronica Teucrium* (22), *Vicia Americana* (60) and var. *lincaris* (5) (6), *V. cassubica* (319) (359), *V. Cracca*, *V. Faba* (214), *V. gemella* (383), *V. hirsuta* (383), *V. oroboides*, *V. pallida*, *V. sativa* (107) (214) (260) (383) (384), *V. sepium*, *V. sylvatica*, *V. unijuga*, *Vincetoxicum officinale* (22) (344).

Distribution.—EUROPE: Britain, France, Spain, Portugal (260) (355), Belgium, Netherlands, Switzerland, Italy, Germany, Austria-Hungary, Servia (318), Denmark, Norway, Sweden, Finland, Russia.

AFRICA: Algeria, Canaries (253).

ASIA: Turkey (Marash), Cyprus, Transcaucasia (338), Persia (233) (389), Turkestan, Siberia (Minussinsk), Soongaria, India, Japan.

NEW ZEALAND.

AUSTRALIA : Victoria (225).

NORTH AMERICA : United States—Maine, Massachusetts, New York, Pennsylvania, Maryland, New Jersey, Delaware, Virginia, Carolina, Ohio, Michigan, Indiana, Alabama, Illinois, Mississippi, Wisconsin, Missouri, Iowa, Minnesota, South Dakota, Nebraska, Kansas, Montana, Idaho, Wyoming, Colorado, Utah, Nevada, California, Washington ;—Canada, New Brunswick, Ontario, Manitoba.

E. polygoni (*E. communis* and *E. Martii* of most authors) is the commonest and the most variable species of the Erysiphaceae. As may be seen from the specific description given above, the present species is variable in every character ; nature of the mycelium, size of the perithecium, number, length, color, etc., of the appendages, number of asci and spores. It may seem, at first sight, undesirable to allow so wide a range of variation to a single species, yet from the study of a very considerable amount of material it has seemed to me impossible—so closely are the extreme forms linked to the type—to separate any of these forms as varieties, much less as species. As a matter of fact, although several forms here included under *E. polygoni* have been separated as distinct species, *E. polygoni* itself has been frequently confused with *E. cichoracearum*, as a glance at any large herbarium will show. Before attempting to separate and give names to the most striking forms of *E. polygoni*, it seems to me wiser to collect the vast number of forms of the two mildews (recorded as parasitic on no less than 602 species of plants) round the two specific centers here distinguished as *E. polygoni* and *E. cichoracearum*.

Moreover the forms which have been hitherto separated from *E. polygoni* as distinct species are certainly not satisfactorily defined.

E. Martii (*E. pisi*) still appears in many works as distinct from *E. polygoni*, although the name appears practically to be one applied to examples of *E. polygoni* on certain host-plants quite as much as to a form based on any morphological characters. Originally, *E. Martii* was distinguished from "*E. communis*" by Léveillé on the ground of possessing colorless appendages; De Bary, however, finding that this supposed character did not hold good, united the two, and many subsequent authors followed this

arrangement. Winter (394) and Schroeter (319), however, still keep the two apart as distinct species, although both authors admit that, perhaps, the character of colored or colorless appendages is variable. As a matter of fact, as Burrill (60) has pointed out, many of the specimens in the exsiccati quoted by Winter as belonging to *E. Martii* have distinctly colored appendages. An examination of specimens named *E. Martii* in herbaria shows at once that in the forms of the present species, no satisfactory systematic character exists in the absence or presence of color in the appendages, as a complete series of connecting links occurs, often, even in specimens on the same plant, as may be seen in some examples on *Lupinus*. In many cases, though not in all, the absence of color is dependent merely on the age of the specimen as at full maturity colorless appendages frequently become dark brown. *E. Martii*, therefore, I think, may be safely considered a synonym of the present species.

Oudemans (263) has attempted to separate certain forms of *E. polygoni* by the number of spores in the ascus: *E. umbelliferarum* on plants belonging to the Umbelliferae (*e. g.*, *Anthriscus*, *Heracleum*) is stated to have 3–4 spores; *E. communis* and *E. Martii* (on *Polygonum*, *Hypericum*, etc.), 4–8 spores. These characters, however, altogether fail, and it need only be mentioned that on *Hypericum* and *Polygonum* we quite commonly find asci containing only 3 spores, while 3–6 spores occur frequently in specimens on *Heracleum*, etc. It will certainly be admitted by any one dealing with sufficient material of *E. polygoni* that the number of spores varies from 3–8 in this species.

E. umbelliferarum (*E. heraclei*) is generally separated, however, not by the number of spores, but by the shape of the conidia. De Bary first pointed out this character when founding the species, describing the conidia of *E. communis* as "ellipsoidea" and those of *E. umbelliferarum* (on *Angelica*, *Chaerophyllum*, *Anthriscus*, *Pastinaca*, *Falcaria* and *Heracleum*) as "exacte cylindrica"; further remarking "dass diese Art *E. umbelliferarum* von *E. communis* durch die Perithecien kaum verschieden ist. Dagegen ist sie ausgezeichnet durch die Form der Conidien, welche genau walzenförmig, an beiden Enden flach, und mindestens (doch nicht immer) sehr langgestreckt sind. Bei den vorher genannten Arten

allen haben die Conidien die (im Profil elliptische) Gestalt einer schmalen an den Enden abgerundeten Tonne."

Winter, Schroeter, and others, have followed De Bary in maintaining *E. umbelliferarum* as a distinct species, confined to Umbelliferae and distinguishable from *E. polygoni* (*E. communis*) only by the shape of its conidia. I have, however, found generally in studying specimens of *Oidium* in the fresh state that the shape (and size) of the conidium is subject to so much variation that I am strongly inclined to doubt the advisability of employing such characters for systematic purposes, and especially of considering them of specific importance. In the present case, although only examination of living material of the forms on the different host-plants can satisfactorily settle the whole question, it appears to me very doubtful from the study of herbarium material, if the cylindrical form of conidium is exclusively confined to examples on Umbelliferae and whether conidia of both shapes do not occur in the same specimen. Certainly the conidia of *E. polygoni* on some host-plants, *e.g.*, *Clematis alpina*, are more or less cylindrical. No differences are to be found in the perithecial form of fruit of examples on Umbelliferae to those of *E. polygoni* on other hosts.

In dealing with the variation in mycelial characters we come to two very interesting forms, viz, *E. liriodendri* Schwein and *E. densa* Berk.

E. liriodendri is maintained as a species by Burrill (60), who remarks that it " may be identified by its abundant, white mycelium, especially on the young stems."

I have examined many specimens of this form on *Liriodendron*, and have found no characters except the persistent mycelium by which it can be separated from typical *E. polygoni*. When occurring on the stems, *E. liriodendri* has a thin persistent mycelium, but it is to be noted that on the leaves the mycelium is subevanescent, and then the fungus cannot possibly be distinguished from many of the forms of *E. polygoni* on other hosts. Nor can the persistent mycelium on the stem be considered absolutely peculiar to the form on *Liriodendron*; in the herbarium of the Upsala Museum there is a specimen of *E. polygoni* on the stems of *Thalictrum aquilegifolium* in which the mycelium is persistent, and in some places almost pannose in consistency. This specimen

forms a quite similar state to that of *E. liriodendri* and moreover quite commonly on *Thalictrum minus*, *Polygonum aviculare*, etc. *E. polygoni* shows a tendency towards developing a persistent mycelium.

More marked than *E. liriodendri* is a form on *Diervilla Japonica* from Sapporo, Japan (K. Miyabe and N. Hiratsuka) sent to me by Professor Miyabe under the mss. name of *Erysiphe diervillae*, with these notes, "*E. diervillae* ripens its perithecia only in the early spring of the next year. Mycelial layers are formed on the young branches and persistent capsules. Perithecia 120–135 μ, asci 37–45 × 67–86 μ, ascopores (6–7) 11 × 22 μ." This form on *Diervilla* covers the stem and fruit of the host-plant with soft dense patches of persistent mycelium, in which the perithecia are more or less imbedded. Except in these characters, however, the fungus is not different from *E. polygoni*, and it is to be noticed that here and there on the stem, perithecia occur from which the mycelium has almost or quite disappeared, and so are more or less naked as in ordinary *E. polygoni*.

Even more striking is the plant published by Berkeley as *Erysiphe densa*, on *Aristotelia racemosa* from New Zealand. Berkeley remarked: "This differs from *E. Martii* Lév. merely in its thick persistent mycelium, which gives it a very lichenoid appearance, especially when on the upper surface of the leaf." There is a fine series of "*E. densa*" in the Kew Herbarium, and the specimens show in a very clear manner how variable the nature of the mycelium is in the present species, even on the same host-plant. In this series, the mycelium on most of the leaves is very dense and compact, more or less thick, and lichenoid, either limited to spots or extending more or less completely over the whole upper surface of the leaf. The fungus in this condition seems quite distinct from *E. polygoni*, in which a persistent lichenoid mycelium has not been recorded on any host. On other leaves of *Aristotelia* in this series, however, we find only a thin layer of persistent mycelium, from arachnoid to merely pruinose in consistency. Finally, on some leaves we find an absolutely evanescent mycelium. I can find no difference in the perithecia from those of *E. polygoni*, and under the circumstanees, considering the variable nature of the mycelium, I do not think *E.*

densa—although so marked in its extreme state—can be given even a varietal rank. Nothing can be more marked, at first sight, than the forms of *E. taurica* with persistent densely compacted mycelium, yet we find that this species may not uncommonly occur with an evanescent mycelium; in the same way we must, it seems to me, considering the evidence afforded by the forms on *Liriodendron*, *Diervilla* and *Aristotelia*, allow to *E. polygoni* a similar range of variation in mycelial characters.

Karsten, in the second part of Myc. Fenn. has described a species of *Erysiphe* as follows: "*E. vernalis* Karst. Mycelium arachnoideum, saepissime evanidum. Asci in quovis perithecio 8 ovoideo-sphaeroidei, breviter pedicellati 8-spori. Appendiculae sat longae, cum mycelio intertextae. Hab. In ramulis vivis *Alni incanae* fine mensis Maji ad Mustiala semel observata. A sequente [*E. Martii* Lév.] forte non distincta." In the Notiser ur Sällsk. Faun. Fl. Fenn. Förh. **13**: 247 the following further description is given, "Perithecia hemisphaerica, mycelio emersa, fusca, latit. circiter 0.1 mm. Asci 8ni. brevissime pedicellati, ovoidei- vel oblongato-sphaeroidei, longit. circit. 69 mmm., crassit, circit. 39 mmm. Sporae 8nae, sphaeroideo-ellipsoideae, longit. 16–18 mmm., crassit. 11–12 mmm. Appendiculae hyalinae. . . . Species quasi media inter *Erys. graminis* et *Erys. Martii*."

Professor Karsten has kindly sent me specimens (now in the Kew Herbarium) of *E. vernalis*, and after a careful study of the plant and comparison of it with numerous forms of *E. polygoni*, I do not see by what characters it can be separated from this species. It is, nevertheless, a rather marked and extremely interesting form. The fungus occurs on the young shoots of *Alnus incana*; the mycelium is more or less evanescent on the internodes, and the perithecia are here scattered, but at the base of the buds the perithecia become gregarious, and the mycelium is persistent. The perithecia average about 120 μ in diameter, and the appendages are rather long, not much interwoven, hyaline and quite similar in every way to those of many forms of *E. polygoni*. The asci are usually rather numerous, sometimes as many as 15, and may reach to 80 μ in length; in shape they are usually broadly-ovate to ovate-oblong; very rarely, however, they show a tendency to become subcylin-

drical, the 7–8 spores measure about 18 × 12 μ. Many forms of *E. polygoni* approach so closely to all the above characters (this is the case, *e. g.*, with the form of *Albizzia* (*Acacia*) called by Eriksson *E. Martii* forma *acaciae*) that it seems impossible to separate *E. vernalis* from them. On the other hand, *E. vernalis*, shows undoubted affinity with the American species *E. aggregata* on alder-catkins. *E. vernalis* has smaller perithecia, fewer, smaller, less cylindrical asci, and less interwoven appendages; occasionally, however, the asci show a tendency to become subcylindrical and the roundish spores are the same in both plants. It is possible that, if more intermediates occur, *E. aggregata* may have to be regarded as only a well marked variaty of *E. polygoni*.

Magnus has considered the fungus growing on *Caragana arborescens* and *Colutea arborescens* as belonging to the genus *Microsphaera*, and has published it as a new species, *M. caraganae*. I had already seen specimens of this plant on *Colutea* in Syd. Myc. March. 980, and on *Caragana* in Syd. Myc. March. 3718, and had referred them to *E. polygoni*. Professor Magnus has kindly sent me very beautiful specimens (now in the Kew Herbarium) of "*Microsphaera caraganae*, on *Caragana arborescens* Wannsee," and after examining these I still feel convinced that the fungus is nothing but a form of *Erysiphe polygoni*. None of the specimens possess appendages with apical branching of the definite type found in *Microsphaera;* as a rule, the appendages are unbranched, and the branching that does occasionally occur is always quite vague. The appendages are usually about 9 in number, rather distant from one another, septate, and more or less colored towards the base. Occasionally the appendages are as few as four, and the coloring extends almost to the apex. A few perithecia were observed in which the appendages, 4 or 5 in number, were stouter than usual, rounded at the end, and colored deep brown throughout—much recalling the American form of *E. polygoni* on *Parnassia* mentioned below. As Magnus points out, there appear often among the normal appendages very short rudimentary ones. This character, however, as well as that of the few and distant appendages, can be in no way considered peculiar to the form on *Caragana* and *Colutea*, as both are found in many common forms of undoubted *E. polygoni*. In the present form the appendages become more

free from the mycelium than is usually the case, and, as the perithecia are often densely gregarious, give a slightly floccose appearance to the leaf. This habit (which is found in some species of *Microsphaera*), however, is not confined to the plant on *Caragana* and *Colutea*, as in the forms of *E. polygoni* on *Lupinus* (European and American) exactly the same appearance is found.

A very striking form of *E. polygoni* occurs in America on *Parnassia Caroliniana*. I have seen two specimens of this, one from Madison, Wisconsin (Halsted and Tracy, August, 1893), ex herb. S. M. Tracy (in the Herbarium of the Missouri Bot. Garden), where the fungus is labelled "*Erysiphe spatulata*"; the other from Syracuse, New York (L. M. Underwood, July, 1899), named *Erysiphe communis*. The striking feature of this form is the presence of few, brown, usually short, stout, rigid appendages. The perithecia are 70–85 μ in diameter, the asci 3–6, 50–58 × 30–36 μ, spores 3–5, very rarely 2, 20 × 10 μ. Except in the appendages, the fungus agrees well with certain common forms of *E. polygoni*. In the Wisconsin specimen the appendages give a very distinct appearance to the form; they are usually few and very short, in fact often rudimentary and only about a quarter of the diameter of the perithecium in length, very stout (about 10 μ wide), and dark brown throughout; in the New York specimens, however, most of the perithecia have longer appendages, 3–4 times, or more, the diameter of the appendages, paler towards the apex, and 7–8 μ wide, and it is then at once seen that the present plant is closely connected with many forms of *E. polygoni* on various host-plants, *e. g.*, some specimens on species of *Clematis* and on *Caragana arborescens* are very similar. On the whole, I am inclined to regard the fungus on *Parnassia* rather as a starved form of *E. polygoni*, caused perhaps by growing on an unsuitable host-plant than as a true variety.

(Since the above remarks were written, Halsted (157*) has founded a new genus, *Erysiphopsis*, on this fungus on *Parnassia Caroliniana*. I am quite unable to follow this treatment. Any one at all acquainted with the forms of *Erysiphe polygoni* will, I think, at once admit that the fungus in question clearly belongs to the genus *Erysiphe*, and is, moreover, I believe, so close to certain forms of this species that (as mentioned above) it seems doubtful if it can be separated even as a variety.)

The plant issued as "var. *delphinii*" (on stems of *Delphinium*) Ell. & Everh. N. A. Fung. no. 835 does not differ from many common forms of *E. polygoni*, and cannot be separated from the type.

An interesting *Erysiphe* has been sent to me by Professor Miyabe from Japan (Kyoto, April, 1899, coll. T. Nishida), growing on *Quercus glauca*, which I cannot separate from *E. polygoni*. This form has a rather distinct habit; the persistent, thin, subcrustaceous mycelium forms definite patches on the upper surface of the leaf, and on these the perithecia are more or less gregarious. The diameter of the perithecium is about 90 μ; the asci are 4–6, ovate to ovate-oblong, often without a stalk, 50–58 × 30–35 μ, spores 4–6, 21 × 10 μ. The appendages are from 2 to 3 times the diameter of the perithecium, rather numerous but distinct, colorless, becoming shining, and are more or less irregularly bent, or geniculate, at intervals. Except in the rather marked habit, the fungus does not differ in any way from many common forms of *E. polygoni*. This is the first record of the occurrence of an *Erysiphe* on *Quercus* in the Old World. The Californian *E. trina* on *Quercus agrifolia* is quite distinct from the present form.

The record of *E. Martii* by Cooke (83) on *Populus ciliata* is an error, the fungus being *Uncinula salicis*. The specimens published as *E. Martii* in Rab. Fung. Eur. 1737, on *Rubia peregrina*, and in Roumeg. Fung. Gall. nr. 3316 on *Asperula odorata* are some sphaeriaceous fungus.

E. polygoni is the cause of the disease known as the "blight" or "mildew" of several cultivated plants of economic importance.

In the first place, it causes the "bean" and "pea blight," well known to market gardeners. Bessey (40), speaking of this disease in the United States, says, "pea blight has for many years been very destructive to late peas in the West; it has, in fact, rendered the growth of the later varieties in some instances almost impossible." As regards remedies against the disease, Galloway (135) mentions a case where a crop of beans badly mildewed was "thoroughly dusted with flowers of sulphur, and in a week the fungus had entirely disappeared, and the plants produced a good crop." The following advice is given: "A powder made by mixing equal parts of air-slacked lime and flowers of sulphur

will be found a very good remedy. The powder should be dusted on the foliage at the first appearance of mildew and the operation repeated every ten or twelve days, or more often if there is an abundance of rain. If one has a spraying machine, a solution made by dissolving 3 ounces of carbonate of copper in 2 quarts of aqua ammonia diluted to 22 gallons will be found an efficient remedy. This solution should be applied every twelve or fifteen days, beginning at the first appearance of the disease."

The "mildew of turnips" is also caused by *E. polygoni*. Hitherto the fungus causing this disease has been known only in its conidial stage, and has been wrongly identified as *Oidium Balsamii* (Mont. mss.) Berk. & Broome. Worthington G. Smith (329, p. 76) first gave it this name, and described the disease as follows: "*Oidium Balsamii*, Mont., first attracted attention as a pest of turnips in September, 1880, when Prof. James Buckman, F.L.S., of Bradford Abbas, Dorsetshire, saw the fungus growing in such profusion over hundreds of acres of Swede turnips that the boots and clothes of persons walking through the turnip fields were whitened with the spores. Until 1880 the fungus was not supposed to be common in Britain. . . . Important as this *Oidium* is to agriculturists, no one at present has worked out its life-history, or knows whence it comes, where it goes, what other form it takes, or how it hibernates through the winter. The fungus is more prevalent when a humid September follows on a dry August." Trail (365) notices the disease, and says of "*Oidium Balsamii*," "It is of considerable practical interest, since it attacks various cultivated plants. Near Aberdeen [Scotland] I have seen it in great plenty upon turnips, preferring the Swedish to the common yellow turnip."

In the beginning of November, 1898, my attention was directed to some fields of turnips, near Reigate, Surrey, England, which were, in places, quite white with mildew. On examination it was found that this appearance was caused by the presence of an *Oidium*, which agreed with specimens in the Kew Herbarium named *O. Balsamii*, on turnips, by Worthington G. Smith. *O. Balsamii* (Mont. mss.) is thus described by Berkeley and Broome (38): "Candida, articulis doliiformibus utrinque angustatis. On the leaves of *Verbascum nigrum*, Wothorpe, Aug. 23, 1853. This

species was sent from Milan by Balsamo to Dr. Montagne, under the name of *Oidium Tuckeri*, but it is a very different species, distinguished by the very peculiar shape of its spores. The length about .0015. Balsamo's plant grew on *Verbascum montanum*. No *Erysiphe* has at present been observed in connection with this species. The same species occurs on strawberries, to which it is very destructive. See Gard. Chron., April 15, 1854."

In Berkeley's herbarium at Kew there is the specimen of *O. Balsamii* from Montagne's herbarium referred to above, and the conidia here are more or less barrel-shaped, ranging from 28–30 × 14–18 μ in size (Fig. 161). In the turnip mildew the conidia are subcylindrical, with rounded, unconstricted ends, 30–40 × 13–15 μ, produced singly on the conidiophores (Fig. 162). Probably *O. Balsamii* on species of *Verbascum* is the conidial stage of *Erysiphe cichoracearum* or *E. taurica;* the *Oidium* on strawberries is probably that of *Sphaerotheca humuli.*

After a careful search on the *Oidium*-infected turnips, referred to above, I found on a few plants some scattered patches of the perithecia of *Erysiphe polygoni.* These perithecia occurred chiefly on the stem and petioles, only very rarely on the leaves. The perithecia are mostly gregarious in scattered patches among the subpersistent mycelium and contain about 6 asci, with 4–5 spores. The appendages are colorless, or occasionally one here and there is colored, and are variable in number and length, usually about 2–4 times the diameter of the perithecium. The turnip crop was very poor, but as the plants were infested with "green-fly" (*Aphides*), it is impossible to say to what extent the inquiry was caused by the fungus alone. The remedies given above for the "pea blight" would probably be equally efficacious here.

Var. **sepulta** (Ell. & Everh.). [Fig. 157]

Erysiphe sepulta Ell. & Everh. Bot. Gaz. **14**: 286. 1889.

E. cichoracearum DC. Burr.; Ell. & Everh. N. Amer. Pyren. 12 (form on *Bigelovia graveolens* only). 1892; Jones, Proc. Calif. Acad. Sci. II. **5**: 731. 1895.

Amphigenous; mycelium evanescent or subpersistent; perithecia large, 140–220 μ in diameter, averaging 180 μ, cells indistinct; appendages numerous, rather short, delicate, colorless, hya-

line, densely interwoven; asci very numerous, from 20 to 34, or more, large, broadly ovate-oblong to subcylindrical or subpyriform, 70–100, usually about 85, × 30–36 μ, usually stalked; spores 4–6, 20–22 × 10–12 μ.

Host.—*Bigelovia graveolens* and var. *albicaulis*.

Distribution.—NORTH AMERICA: United States;—Montana, Wyoming, Colorado, Utah (179).

Two forms of *Erysiphe* occur on species of *Bigelovia* (*B. graveolens*) and its var. *albicaulis*, and *B. viscidiflora* (*B. Douglasii*) in the United States. The *Erysiphe* on *B. viscidiflora* has regularly bisporous asci, and although a marked form from its large size must be referred to *E. cichoracearum*, as has already been done by American mycologists. The *Erysiphe* on *B. graveolens* is very different. The perithecia, which occur in scattered patches on the stem, are at first more or less immersed and firmly imbedded in the pannose tomentum of the host-plant; at maturity, however, the perithecia break through the tomentum of the stem, and appear in naked black patches. The perithecia are, as a rule, very large, and contains a great number of asci. The asci are large, rather irregular in shape, sometimes subcylindrical or somewhat pyriform, and contain constantly 4–6 spores, are about 22 × 11 μ in size. These characters give the plant, in my opinion, a position somewhat intermediate between *E. polygoni* and *E. aggregata*; from the former it differs in the larger size, and larger and more numerous asci, from the latter in the more interwoven appendages and 4–6 longer spores. American mycologists have placed this form in *E. cichoracearum*, merely for the reason, it appears that, as mentioned above, on another species of *Bigelovia* (*B. viscidiflora*), *E. cichoracearum*, with its normal bisporous asci, is found. We must remember, however, that many cases occur in which distinct species of the Erysiphaceae are found on even the same species of host-plant, and very commonly we find two or more species of mildew on different species of host-plants belonging to the same genus.

The name *E. sepulta* was published in the Bot. Gazette, **14**: 286. 1889, as follows: "*Erysiphe sepulta* Ell. & Everh. n. sp. This species is so named only provisionally, and may yet prove to be only an old species under peculiar circumstances. . . It comes so near to *E. cichoracearum* that it may well be doubted if it be a new species; but the perithecia appear imbedded in the woolly

coat of the host." Burrill (60), in his description of *E. cichoracearum* says: "Sporidia large, quite uniformly 2, but occasionally varying to 3 or even 4" (on *Bigelovia* 5 or 6), and, under the same species, adds the further remarks. "A form on *Bigelovia graveolens* has 20–30 asci, many of which have 3–5, and perhaps more, sporidia, and the appendages are short and almost hyaline. Taken by itself, it could hardly be admitted as belonging to the present species. Ellis and Everhart provisionally propose the name *E. sepulta* for it. But on *Bigelovia Douglasii*, growing with the preceding, the fungus is in all characteristics the same, except that the sporidia are uniformly 2, in the specimens examined, and so reported by others. The asci are often as many as 30 in both cases, a number much greater than commonly given for typical *E. cichoracearum*. On other host species the number of asci is exceedingly variable, mostly only 4–8, but in some collections east of the Mississippi river reaching 20, with apparently no way of distinguishing different species among the variable forms. Those on *Bigelovia* are indeed further aberrant, but it does not seem wise to separate one or both as specifically distinct, either from each other, or from those with which they are undoubtedly allied on the host-plants enumerated above."

Jones (179), in "*E. cichoracearum*" on *Bigelovia graveolens* from Utah, remarks: "asci numerous, 15–20 or more; sporidia uniformly 4–6, much smaller than in the type. . . The characters given above would suggest a relationship to *E. communis* rather than to *E. cichoraccarum*, but no forms of that species have so far been reported on Compositae."

It may, however, be pointed out that, among Compositae, a form of *E. polygoni* occurs on the stem of species of *Carduus* and *Cnicus*, which although very unlike the var. *sepulta* in its small size, yet approaches it in possessing numerous asci (23 or more). The form of *E. polygoni* described as *E. vernalis*, also, must be considered in dealing with the question of the position of the present plant.

2. E. CICHORACEARUM DC. [Figs. 140, 151]

Mucor Erysiphe Leyss. Fl. Hal. 305. 1783.

Erysiphe cichoraccarum DC. Fl. Fr. **2**: 274. 1805; Wint.;

Rabenh. Krypt. Fl. Deutschl. 1^2: 33. 1884; Karst. Act. Soc. Faun. Fl. Fenn. 2: 94. 1885; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. 2: 404. *f. 4* (excl. syn. *E. sepulta*). 1887; Atkins. Journ. Elisha Mitch. Sci. Soc. 7: 65. 1891; Burr.; Ell. & Everh. N. Amer. Pyren. 12 (excl. syn. *E. sepulta*). 1892.

E. varium Fr. Obs. Myc. 1: 206 (partim). 1815; 2: 366 (partim). 1818.

Alphitomorpha communis, var. *cichoracearum* Wallr. Berl. Ges. Nat. Freund. Verh. 1: 31. 1819.

A. depressa Wallr. Berl. Ges. Nat. Freund. Verh. 1: 34. 1819; Wallr. Fl. Crypt. Germ. 2: 758. 1833.

A. circumfusa Schlecht. Berl. Ges. Nat. Freund. Verh. 1: 49. 1819.

A. bardanae Wallr. Ann. Wett. Ges. 4: 239. 1819.

A. cynoglossi Wallr. Ann. Wett. Ges. 4: 240. 1819.

A. artemisiae Wallr. Ann. Wett. Ges. 4: 240. 1819.

Erysibe biocellata Ehrenb. N. Act. Acad. Leop. Car. Nat. Cur. 10: 211. *pl. 13*. 1821; Lk.; Willd. Sp. Pl. 6: 109. 1824.

E. depressa, var. *artemisiae* Wallr. Ficin. & Schub. Fl. Gegend. Dresd. 2: xix. 1823.

E. communis Schlecht. Fl. Berol. 2: 168. 1824; Rabenh. Deutschl. Krypt. Fl. 1: 232 (partim). 1844.

E. circumfusa Schlecht. Fl. Berol. 2: 169. 1824; Lk.; Willd. Sp. Pl. 6: 109. 1824; Rabenh. Deutschl. Krypt. Fl. 1: 232 (partim). 1844.

E. depressa Schlecht. Fl. Berol. 2: 169. 1824; Lk.; Willd. Pl. 6: 110. 1824; Rabenh. Deutschl. Krypt. Fl. 1: 232 (partim). 1844.

E. communis, var. *cichoracearum* Lk.; Willd. Sp. Pl. 6: 107. 1824.

E. lamprocarpa, var. *plantaginis* Lk.; Willd. Sp. Pl. 6: 109. 1824.

Erysiphe artemisiae Grev. Fl. Edin. 459. 1824.

E. arctii Grev. Fl. Edin. 460. 1824.

E. asperifoliorum Grev. Fl. Edin. 461 (partim). 1824.

E. bardanae Chev. Fl. Par. 1: 381. 1826.

E. communis Fr. Syst. Myc. 3: 239 (partim). 1829; Berk.; Sm. Eng. Fl. 5: 325 (partim). 1836.

E. communis, var. *cichoracearum* Duby, Bot. Gall. **2** : 869. 1830.

A. lamprocarpa, var. *plantaginis* Duby, Bot. Gall. **2** : 869. 1830.

E. compositarum Duby, Bot. Gall. **2** : 870 (excl. var. *cynarae*). 1830.

E. knantiae Duby, Bot. Gall. **2** : 870. 1830.

Alphitomorpha horridula Wallr. Fl. Crypt. Germ. **2** : 755 (partim). 1833.

A. lamprocarpa, var. *plantaginis* Wallr. Fl. Crypt. Germ. **2** : 758. 1833.

A. communis Wallr. Fl. Crypt. Germ. **2** : 758 (partim). 1833.

Erysiphe ambrosiae Schwein. Syn. Fung. Am. Bor. 270. 1834 ; Sacc. Syll. Fung. **1** : 22. 1882.

E. verbenae Schwein. Syn. Fung. Am. Bor. 270. 1834 ; Sacc. Syll. Fung. **1** : 22. 1882.

E. phlogis Schwein. Syn. Fung. Am. Bor. 270. 1834 ; Sacc. Syll. Fung. **1** : 21. 1882.

E. asterum Schwein. Syn. Fung. Am. Bor. 270. 1834 ; Sacc. Syll. Fung. **1** : 23. 1882.

Erysibe lamprocarpa Rabenh. Deutschl. Krypt. Fl. **1** : 232 (partim). 1844.

E. horridula Rabenh. Deutschl. Krypt. Fl. **1** : 235 (partim). 1844.

Erysiphe scorzonerae Cast. Cat. Pl. Mars. 189. 1845.

E. lamprocarpa Kickx. Fl. Crypt. Env. Louv. 140 (partim). 1835 ; Dur. & Mont. Fl. d'Algér (Crypt.) 567. 1846–9 ; Lév. Ann. sci. nat. III. **15** : 163. *pl. 10. f. 31* (partim). 1851 ; Cooke, Micr. Fung. 220. *pl. 12. f. 250, 251.* 1865 ; de Bary, Beitr. Morph. Phys. Pilz. **1** : § xiii. 49. 1870 ; Cooke, Handb. Brit. Fung. **2** : 650. *f. 317.* 1871 ; Karst. Myc. Fenn. 192 (partim). 1873 ; Sacc. Syll. Fung. **1** : 16. 1882 ; Jacz. Bull. l'Herb. Boiss. **4** : 730. 1896 ; Oudem. Rév. Champ. Pays.-Bas. **2** : 94. 1897.

E. orontii Cast. Supp. Cat. Pl. Mars. 52. 1851.

E. linkii Lév. Ann. sci. nat. III. **15** : 161. *pl. 10. f. 20.* 1851 ; Cooke, Micr. Fung. 220. *pl. 12. f. 248, 249.* 1865 ; Cooke, Handb. Brit. Fung. **2** : 650. 1871 ; Karst. Myc. Fenn. **2** : 191.

1873 ; Sacc. Syll. Fung. 1 : 16. 1882 ; Wint.; Rabenh. Krypt. Fl. Deutschl. 1 : 30. 1884 ; Karst. Act. Soc. Faun. Fl. Fenn. 2 : 92. 1885 ; Jacz. Bull. l'Herb. Boiss. 4 : 727. 1896 ; Oudem. Rév. Champ. Pays.-Bas. 2 : 93. 1897.

E. Montagnei Lév. Ann. sci. nat. III. 15 : 169. *pl. 11. f. 36* (excl. syn. *E. lappae* Cast). 1851 ; Cooke, Micr. Fung. 220 (excl. syn. *E. compositarum*, var. *cynarae*). 1865 ; Cooke, Handb. Brit. Fung. 2 : 651. 1871 ; Sacc. Syll. Fung. 1 : 17. 1882.

E. horridula Lév. Ann. sci. nat. III. 15 : 170. *pl. 11. f. 37.* 1851 ; Cooke, Journ. of Bot. 4 : 98. 1866 ; Cooke, Handb. Brit. Fung. 2 : 652. 1871 ; Karst. Myc. Fenn. 2 : 194. 1873 ; Sacc. Syll. Fung. 1 : 17. 1882 ; Oudem. Rév. Champ. Pays.-Bas. 2 : 96. 1897.

Uncinula adunca, var. *artemisiae* Prod. Fl. Bat. 2 : 33. 1866.

Erysiphe spadicea Berk. & Curt. Grevillea, 4 : 159. 1876 ; Sacc. Syll. Fung. 1 : 18. 1882.

E. horridula, var. *cynoglossi* Sorok. 147. *pl. 88 (13). f. 191–194.* 1889.

E. lamprocarpa, var. *plantaginis* Sorok. Rev. Myc. 148. *pl. 89 (15). f. 240.* 1889.

Erysibe cichoracearum DC. Schroet.; Cohn's Krypt. Fl. Schles. 3 : 238. 1893.

Exsicc.: Westend. Herb. Crypt. Belg. 226, 409, 410, 411, 553 (f only), 1058 ; Rab. Fung. Eur. 561, 673, 1059, 1067, 1149, 1325, 1523, 2320, 2520 ; Rab. Herb. Myc. ed. 2, 470, 471, *485, 486, *669 ; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 403, 518, 1108 (B only), 1109 (A only), 1304 (A only), 1516, 1517 ; *ed. 2, ser. 1, 111, 508 (B only), 814, 1016, 1017 ; de Thüm.; Fung. austr. 237, 452, 456, 754, 856, 1043, 1144, *1145, 1247, 1250; de Thuem. Myc. univ. 55, 449, 1353, 1840 ; *de Thuem. Fung. exot. dec. 32, 34 ; Oudem. Fung. Neerl. Exsicc. 75, 76, 160 ; Roumeg. Fung. Gall. exsicc. 2339, 3738 ; Roumeg. Fung. Sel. Gall. Exsicc. 261, 533 ; Fckl. Fung. Rhen. 648, 650, 652, 653, 655, 657, 658, 670, 673, 674, 688, 1567, 1739, 1740 ; *Seym. & Earle, Econ. Fung. 46, 293a and b, 295a and b, 305, 321, 346 ; *Ell. & Everh. Fung. Columb. 312, 313, 613 ; Syd. Myc. March. 652, 656, 840, 1145, 1146, *1147, 1148, 2326, 2327, 2766, 3051, 3460, *3918, *4015 ; *Gandog. Fl. Alger. Exsicc. 1981 ; Sacc.

Myc. Ven. 608, 904; Bri. & Cav. Fung. par. 263, 264; Rehm. Ascom. 396, 397; Cooke, Fung. Brit. Exsicc. 97, 199, *200, 466; ed. 2, 285, 287; Vize. Fung. Brit. 96, 199; Ayres. Myc. Brit. 77; *Erikss. Fung. Par. Scand. 37a, 146, 147a and b, 148b, 289, 339; *Fl. Exsicc. Austr.-Hungar. 1173; Ell. & Everh. N. Amer. Fung. 2916, 3006; Rav. Fung. Car. Exsicc. 69; *Kneiff. & Hartm. Pl. Crypt. Bad. 13, 161; Wahrlich, Parasit. Pilz. 25, 26, 27 (in Herb. Hort. Imp. Petropol.); Lib. Pl. Cr. Ard. 183 (in Herb. Jarb. Bot. Bruxelles).

Sub *Erysiphe polygoni;* Rab. Fung. Eur. 1066, 1742, 1917; *Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 1108B, ed. 2, ser. 1. 509A; *Krieg. Fung. Saxon. 826; Syd. Myc. March. 1144; *Karst. Fung. Fenn. 785; Berk. Brit. Fung. 202; Klotsch. Herb. Myc. 60; Westend. Herb. Crypt. Belg. 1058; Roumeg. Fung. Gall. Exsicc. 2271; de Thüm. Fung. austr. 1250; Fckl. Fung. Rhen. 670.

Sub *E. taurica;* Roumeg. Fung. Sel. Exsicc. 4564.

Sub *Sphaerotheca Castagnei;* Rab. Fung. Eur. 1048, 1051, 1916; de Thuem. Fung. austr. 441; Cooke, Fung. Brit. Exsicc. ed. 2, 591, 592; Sacc. Myc. Ven. 630.

Sub *Erysiphe galeopsidis;* Westend. Herb. Crypt. Belg. 409; Desmaz. Pl. Cr. Fr. ser. 1, 1517.

Amphigenous; mycelium usually evanescent, sometimes persistent and effused, usually white, rarely with a pinkish tinge; perithecia sub-globose or globose-depressed, often becoming concave, gregarious or scattered, 80–140 μ in diameter, very rarely 140–180 μ, cells variable in size, often very distinct, and 10–20 μ wide, sometimes smaller, 10 μ wide, and obscure; appendages very variable, long or short, brown or sometimes colorless, usually numerous, densely interwoven, vaguely branched, septate, light or dark-brown throughout, and from 2–4 times the diameter of the perithecium, but sometimes very few, and short or even rudimentary; asci usually numerous, about 10–15, but varying from 4–25, very rarely as many as 36, variable in size and shape, from narrowly ovate or subcylindrical to broadly ovate, or rarely subglobose, more or less stalked, 58–90 × 30–50 μ; spores 2, rarely (and never uniformly) 3, 20–28 × 12–20 μ, usually about 24 × 14 μ.

Hosts.—Achillea Millefolium, A. Ptarmica, Actinomeris squarrosa, Adenostyles alpina (3), *A. viridis, Ambrosia artemisifolia, A.*

doronicoides, *H. giganteus*, *H. grosse-serratus* (265), *H. Maximiliani*, *H. orgyalis*, *H. petiolaris*, *H. rigidus*, *H. strumosus*, *H. tuberosus*, and var. *subcanescens*, *Helichrysum arenarium*, *Hieracium albiflorum*, *H. boreale* (205*), *H. Canadense* (61), *H. incisum* (230), *H. lycopsifolium*, *H. murorum* (3) (345), *H. prenanthoides*, *H. sabaudum* (214) (263), *H. vulgatum* (319), *Humulus Lupulus* (60), *Hydrophyllum Canadense*, *H. capitatum*, *H. macrophyllum* (324), *H. occidentale* (259), *H. Virginicum*, *Hyoscyamus albus*, *H. niger*, *Hypericum humifusum* (18), *Inula Britannica* (319), *I. Helenium* (272) (363), *I. hirta*, *I. Oculus-Christi*, *I. salicina*, *Iva frutescens* (60), *I. xanthifolia* (363), *Kuhnia eupatorioides*, *Lactuca muralis* (345), *L. pulchella* (6), *L. Scariola*, *L. viminea* (344), *Laportea bulbifera*, *Lapsana communis* (20), *Lithospermum arvense*, *L. officinale* (22) (390), *Lycodesmia juncea*, *Lycopsis arvensis* (107) (214), *Lycopus Europaeus*, *Madia glomerata*, *Mentha aquatica*, *M. arvensis*, *Mertensia maritima*, *M. Sibirica*, *Mikania scandens* (10) (12), *Mimulus luteus* (363), *Myosotis intermedia* (56) (263), *M. sparsiflora* (345), *M. sylvatica* (56), *Napaea dioica*, *Nicotiana Tabacum*, *Onopordon Acanthium* (319), *Onosma simplicissimum* (347), *Parictaria debilis* (6), *P. officinalis* (230), *P. Pennsylvanica*, *Phacelia circinata*, *P. Menziesii*, *Phlomis tuberosa*, *Phlox divaricata*, *P. Drummondii* (366), *P. paniculata*, *Pilea pumila* (265), *Plantago Bellardi*, *P. Coronopus*, *P. Kamtschatica*, *P. Lagopus*, *P. lanceolata*, *P. major* and var. *Asiatica*, *P. maritima*, *P. media*, *P. Psyllium* (214), *Potentilla* sp. (347), *P. bifurca* (350), *P. viscosa* (235), *Prenanthes alba* (60), *P. purpurea*, *Prunella vulgaris* (107), *Pulmonaria mollis*, *P. officinalis*, *Rudbeckia hirta*, *R. occidentalis* (363), *Rumex Acetosella* (319), *Salvia glutinosa* (15) (73*) (271) (272), *Saussurea salicifolia*, *Scorzonera hirsuta* (66), *S. Hispanica*, *S. humilis*, *Scutellaria lateriflora*, *Senecio hydrophilus*, *S. sylvaticus*, *S. vulgaris*, *Sesbania* (159), *Silphium terebinthinaceum*, *Solanum Carolinense*, *Solidago Canadensis*, *S. Missouriensis* (6) (386), *S. nana*, *S. occidentalis* (6), *S. rigida* (6), *S. serotina*, *Sonchus arvensis*, *S. asper*, *S. oleraceus*, *Stachys palustris* (199) (363), *Stevia* sp., *Symphytum officinale*, *S. tuberosum*, *Tanacetum vulgare*, *Taraxacum officinale* (3) (132) (163) (176) (177) (271) (272) (290), *Tecoma radicans* (265), *Teucrium Canadense* (366), *T. Chamaedrys* (237), *Tragopogon porrifolius*, *T. pratensis*, *Trigonella* (206), *Valeriana officinalis*,

Verbascum nigrum, *V. phlomoides* (20) (230) (272), *V. pulverulentum* (319), *V. thapsiforme* (263), *V. Thapsus* (230), *Verbena angustifolia*, *V. Aubletia*, *V. bracteata* (61), *V. hastata*, *V. laevis*, *V. officinalis* (60), *V. stricta*, *V. urticifolia*, *Verbesina encelioides* (363), *V. occidentalis* (9), *Vernonia Baldwini*, *V. fasciculata*, *V. Noveboracensis*, *Xanthium Canadense*, *X. Strumarium*.

Distribution.—EUROPE: Britain, France, Belgium, Netherlands, Switzerland, Italy, Germany, Austria-Hungary, Servia (318), Greece, Denmark, Norway, Sweden, Lapland (192), Finland (192), Russia.

AFRICA: Algeria, Egypt.

ASIA: Persia (389), Turkestan, Siberia (Minussinsk), Japan.

NEW ZEALAND.

NORTH AMERICA: United States—Maine, New Hampshire, Vermont, Massachusetts, New York, Pennsylvania, Maryland, New Jersey, Virginia, North and South Carolina, Ohio, Michigan, Indiana, Alabama, Illinois, Mississippi, Wisconsin, Missouri, Iowa, Minnesota, South Dakota, Kansas, Montana, Idaho, Wyoming, Colorado, Utah, California, Washington. Canada—Newfoundland, New Brunswick, Ontario.

E. cichoracearum, although very variable, is not as a rule a difficult species to recognize under the microscope. In rare cases, it closely approaches certain forms of *E. polygoni*, with which it has been much confused; *E. cichoracearum* and *E. polygoni*, however, must certainly be considered as distinct species. In by far the greatest number of cases, the present species may be at once distinguished by the numerous, regularly 2-spored asci. The comparatively few forms of *E. polygoni* which have numerous asci are always 4–8-spored. Although *E. cichoracearum* shows rarely one or two asci in a perithecium with 3 spores, and although in *E. polygoni*, as a rare exception, an ascus may contain only 2 spores, yet as the result of an examination of many hundred specimens of both species, it appears to me safe to consider the 2-spored ascus as the central specific character of *E. cichoracearum*, and the 3–8-spored ascus as that of *E. polygoni*. Usually unfailing characters are also found in the large wider asci and larger, distinctly wider spores of the present species. Often, moreover, *E. cichoracearum* has a habit, difficult to define, by which it is known from *E. poly-*

goni, as, *e. g.*, on the leaves of *Plantago*, where the gregarious perithecia more or less completely surrounded by the densely interwoven, deep brown appendages give a characteristic appearance. On the other hand, however, especially in cases where the perithecia are small and scattered, forms of *E. cichoracearum* occur which cannot be separated by the lens alone, or even by microscopic examination of any external characters, but in these cases a safe distinction will be found in the regularly 2-spored asci with larger and wider spores. As a rule, too, *E. cichoracearum* is not found with the few distinct appendages characteristic of many forms of *E. polygoni*; on *Hydrophyllum Virginicum*, however, a form occurs with small perithecia (sometimes only 88 μ in diameter), few asci (often only 6), and appendages few and more distinct than usual; the asci, however, are regularly 2-spored.

It must be noted here that *E. cichoracearum* has been frequently stated to possess asci with 3–4 spores. Léveillé described and figured *E. horridula* (the name given to the form of *E. cichoracearum* on *Symphytum* and *Lycopsis*) with 3–4 spores. In Léveillé's own specimens, however, in Berkeley's herbarium at Kew, from the same locality (Magny en Vexin) as that mentioned in Ann. Sci. Nat., the asci are regularly 2-spored. In other specimens on *Symphytum* I have occasionally found 3 spores, but only by way of exception. Léveillé also described *E. lamprocarpa* (the form of *E. cichoracearum* on *Plantago*, etc.) as 4–8-spored, but this was evidently only by a slip, as *E. lamprocarpa* is figured as 2-spored, and is placed in the key in the bisporous section of the genus. *E. spadicea* Berk. & Curt. has been correctly referred to *E. cichoracearum;* the type specimen at Kew shows regularly bisporous asci, although the species was described as having 8 spores.

E. cichoracearum has been confused not only with *E. polygoni*, but also with *E. taurica* and *Sphaerotheca Castagnei*. To *E. taurica* the present species is certainly closely allied, but may be distinguished by the smaller size of the perithecia, asci and spores; *Sphaerotheca* is widely separated by the single ascus.

It has often been stated that *E. cichoracearum* occurs on *Taraxacum officinale*, and in many exsiccati specimens supposed to be this species on this host have been published. All these, how-

ever, have proved on examination to be *Sphaerotheca humuli*, var. *fuliginea*, and there seems reason to doubt if *E. cichoraceaarum* has really ever occurred on *Taraxacum*.

In the case of the species which occurs commonly (in the conidial condition) on the leaves of *Cucumis* and *Cucurbita* in cultivation, the determination has apparently been equally unsatisfactory. Nearly all mycologists (*e.g.*, Léveillé, Fuckel, Jaczwski, Passerini, etc.), refer the fungus to *Sphaerotheca Castagnei;* Schroeter, however, places it under *E. polygoni*, and records the finding of specimens with perithecia on *Cucurbita Pepo*. The perithecial stage of this fungus on *Cucurbita* and *Cucumis* is evidently rare, and in all the herbarium specimens and those in exsiccati (all named *Sphaerotheca Castagnei*) examined I have found only the conidial stage. I have, however, collected specimens on *Cucurbita Pepo*, at Reigate, Surrey, England, in 1898, with a few perithecia, and the fungus here was undoubtedly *E. cichoracearum*, the asci being regularly 2-spored. It is interesting to note that a few American authors have similarly determined the fungus; *e. g.*, Humphrey (169) records *E. cichoracearum* on cucumber (*Cucumis*). It is, of course, possible that more that one species of *Erysiphe* occurs on these host-plants, but in the present case it seems more probable that the fungus has been constantly named *Sphaerotheca Castagnei* merely because this species was originally recorded on these host-plants, and it would be very interesting to know if any example with perithecia of *Sphaerotheca* really exists.

The *Erysiphe* on *Valeriana officinalis* has been referred without exception (by Fuckel, Magnus, Karsten, Schroeter, etc.) to *E. polygoni*, but all the specimens I have seen so named, have proved on examination to be *E. cichoraceaarum*. On the other hand, the *Erysiphe* which occurs on thistles has been referred entirely to *E. cichoraceaarum*, while, as a matter of fact, on the stems of *Cnicus lanceolatus*, etc., an interesting form of *E. polygoni* occurs not uncommonly. Similarly, the *Erysiphe* on *Anchusa* and *Echium* has been referred to *E. cichoraceaarum*, but all the specimens I have seen so named in exsiccati, etc., prove to be *E. polygoni*. The fungus on *Cnicus eriophorus* (in Montagne's herbarium) referred to *E. taurica* by Léveillé (214) is *E. cichoraceaarum*. The *Erysiphe* on species of *Galium*, which has hitherto been referred to

E. polygoni also belongs to the present species, and together with the forms on *Mentha*, *Lycopus* and *Scutellaria* are peculiar in usually showing on the living host-plant no trace of spores in the asci. These forms, as well as their connection with *E. galeopsidis*, are discussed further.

A rather marked form of *E. cichoraccarum* occurs on *Senecio vulgaris* (Margery, Reigate, England, Oct., 1898). Here the mycelium is persistent and covers the stems with a continuous white covering, in which the perithecia are more or less immersed, giving an appearance very similar to that of the forms of *E. polygoni* on *Liriodendron*, *Diervilla*, etc. We not unfrequently find, however, *E. cichoracearum* on other host-plants with a thin effused persistent mycelium on the leaves, as in some American examples on species of *Helianthus* and on *Ambrosia trifida*—sometimes, as in some specimens on *Hydrophyllum Virginicum* the mycelium has a decidedly pink color.

An American form on *Bigelovia viscidiflora* (*B. Douglasii*) (Willis, Montana, Oct., 1888, leg. F. W. Anderson, in Herb. Missouri Bot. Gard.) is remarkable for the often large size of the perithecia, which measure from 100–175 μ, and for the numerous asci, which are sometimes as many as 36. In these characters the fungus approaches both *E. polygoni* var. *sepulta* and *E. taurica*; from the former it differs in the regularly bisporous asci, from the latter in the slightly smaller perithecia, apparently not becoming conspicuously concave or pezizoid, slightly smaller asci and smaller spores. Although this form has been generally referred to *E. cichoraccarum* by American botanists, it must be considered a marked form of this species in the larger perithecia and more numerous asci (I have not seen elsewhere in *E. cichoracearum* perithecia larger than 140 μ in diameter), and certainly makes the nearest approach of any American *Erysiphe* to the Old World species *E. taurica*. I have seen only the one specimen quoted above, and this, unfortunately, for the most part scarcely mature.

In Grevillea, **15**: 98. 1887 the following description of an *Erysiphe* was given: "*E. vitigera* Cke. et Mass. Hypophylla, mycelio floccoso, persistente, peritheciis gregariis, minutissimis (4 mm. diame.), sphaeroideis; appendicibus obsoletis vel cum mycelio intertextis, ascis poriformibus (4 in singulo perithecio)

50 × 30 μ, bisporis. Sporidiis ellipticis, hyalinis, 18 × 9 μ. On leaves of grape vine. Near Melbourne (Mueller). Allied to *E. lamprocarpa*, but apparently distinct from all the disporous species. We have seen the floccose mycelium before, but without perithecia. Hitherto we have not been successful in detecting or identifying the conidia. Destructive to the vines in Australia, but there is no evidence on which to connect it with *Oidium Tuckeri*, but on the contrary, the floccose mycelium is much more woolly, and commonly sterile, at least in so far as we have seen specimens. Leaves and twigs sent to us from Australia last year with a thick cottony-white mycelium, but without fruit of any kind, was probably the same species. It has every appearance of being a dangerous pest." On the sheet with the type-specimens at Kew, there is a drawing (reproduced in Cooke's Handbook of Australian Fungi) (89) or of an ascus with two spores, but on the type-specimens themselves I can find no fungus. The host-plant is one of the forms of *Vitis vinifera* in which the under surface of the leaves, the young wood, etc., are covered with a more or less dense cobwebby tomentum, and it appears that this has been mistaken for floccose mycelium, as of this there is no trace. The description given above of the mycelium—" commonly sterile," etc.—favors this view. It is possible that the perithecia which were seen were stray ones of *E. cichoracearum*.

The fungus described by de Thuemen (354) as *Oidium tabaci*, on *Nicotiana Tabacum*, from Portugal is apparently the conidial form of *E. cichoracearum*, as on specimens sent to me by Professor Gennardius, from Argos, Greece (named *O. tabaci*), there occur numerous perithecia of this *Erysiphe* (see Passinini 272).

3. E. GALEOPSIDIS DC. [Figs. 127–129]

Mucor Erysiphe L. Sp. Pl. **2**: 1186 (partim). 1753.

Erysiphe galeopsidis DC. Fl. Fr. **6**: 108. 1815; de Bary, Beitr. Morph. Phys. Pilz. **1**[3]: §xiii. 49. 1870; Sacc. Syll. Fung. **1**: 16. 1882; Wint.; Rabenh. Krypt. Fl. Deutschl. **1**[2]: 33. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 93. 1885; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 404. 1887; Burr.; Ell. & Everh. N. Amer. Pyren. 13. 1892; Jacz. Bull. l'Herb. Boiss. **4**: 731. 1896; Oudem. Rév. Champ. Pays.-Bas. **2**: 95. 1897.

Alphitomorpha communis, var. *labiatarum* Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 31. 1819.

A. lamprocarpa Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 33. 1819.

A. ballotae Wallr. Ann. Wett. Ges. **4**: 239. 1819.

A. labiatarum Wallr. Ann. Wett. Ges. **4**: 241. 1819.

Erysibe lamprocarpa, var. *galeopsidis* Ficin. & Schub. Fl. Gegend. Dresd. **2**: 305. 1823.

E. lamprocarpa Schlecht. Fl. Berol. **2**: 169. 1824; Lk.; Willd. Sp. Pl. **6**: 108 (excl. var. *plantaginis*). 1824.

E. communis, var. *labiatarum* Lk.; Willd. Sp. Pl. **6**: 106. 1824.

Erysiphe labiatarinm Chev. Fl. Par. **1**: 380. 1826.

E. communis Fr. Syst. Myc. **3**: 239 (partim). 1829.

E. lamprocarpa; var. *galeopsidis* Duby, Bot. Gall. **2**: 869. 1830.

Alphitomorpha lamprocarpa; var. *labiatarum* Wallr. Fl. Crypt. Germ. **2**: 757. 1833.

Erysiphe quisquiliarum Schwein. Syn. Fung. Am. Bor. 270. 1834; Sacc. Syll. Fung. **1**: 23. 1882.

E. cheloues Schwein. Syn. Fung. Am. Bor. 270. 1834; Sacc. Syll. Fung. **1**: 21. 1882.

E. lamprocarpa Kickx. Fl. Crypt. Env. Louv. 140. 1835; Lév. Ann. sci. nat. III. **15**: 163 (partim). 1851; Karst. Myc. Fenn. **2**: 192 (partim). 1873.

Erysibe lamprocarpa Rabenh. Fl. Lusat. **2**: 420. 1840.

E. lamprocarpa, var. *labiatarum* Rabenh. Deutschl. Krypt. Fl. **1**: 232. 1844.

E. galeopsidis DC.; Schroet.; Cohn's Krypt. Fl. Schles. **3**: 237. 1893.

Exsicc.: Fckl. Fung. Rhen. 654, 656; Karst. Fung. Fenn. Exsicc. 172; Sacc. Myc. Ven. 612, *613, 902; Lib. Pl. Crypt. Ard. fasc. 2, 183; Cooke, Fung. Brit. Exsicc. ed. 2, 200 (spec. on *Stachys* only), 596; Desmaz. Pl. Cr. Fr. ed. 1, ser. 1, 516; ser. 2, *110; de Thüm. Myc. Univ. 1252; Syd. Myc. March. 336; Westend. Herb. Crypt. Belg. 409; Rab. Fung. Eur. 1738, 1740, 1741; de Thüm. Fung. austr. 753, *1043, 1142; Roumeg Fung. Gall. Exsicc. 2451; Rab. Herb. Myc. ed. 2, 485; Sacc. Myc. Ven. 613; & 1491 sub *Sphaerotheca Castagnei*; *Kneiff. & Hartm. Pl. Crypt. Bad. 160; *Erikss. Fung. Par. Scand. 37b.

Hosts.—*Ballota nigra*, *Chelone glabra*, *Chelonopsis moschata*, *Eupatorium ageratoides* [?], *Galeopsis Tetrahit*, *G. versicolor*, *Lamium album*, *L. amplexicaule* (176) (230), *L. Galeobdolon*, *L. maculatum*, *L. intermedium*, *L. purpureum*, *Leonurus Cardiaca*, *Marrubium vulgare*, *Phlomis Herba-venti* (172), *Salvia* sp. (176), *S. verticillata* (3) (290), *Scutellaria lateriflora* (61), *S. parvula* (61), (363), *Stachys alpina*, *S. aspera* and vars. *glabra* (324) and *Japonica*, *S. ciliata* and var. *pubens*, *S. cordata* (324), *S. Germanica*, *S. melissaefolia*, *S. palustris*, *S. sylvatica*, *Teucrium Canadense*, *Verbena urticifolia* (10).

Distribution.—EUROPE: Britain, France, Spanish Peninsula (110), Belgium, Netherlands, Switzerland (176), Italy, Austria-Hungary, Denmark, Norway, Sweden, Russia.

ASIA: Turkestan (Seravschan) (206), Siberia (Minussinsk) (311) (347), Japan.

NORTH AMERICA: United States—Massachusetts, New York, Delaware, Michigan, Indiana, Illinois, Wisconsin, Minnesota, South Dakota, Kansas, Montana, Wyoming, Washington; Canada—Newfoundland, Ontario.

De Bary (99, p. 49), in 1870, revived the name *E. galeopsidis* DC. for the *Erysiphe* on *Galeopsis Tetrahit*, *Stachys sylvatica* and *Lamium purpureum*, distinguishing it from *E. lamprocarpa* (*E. cichoracearum*) described as having "haustoria exappendiculata v. appendiculata, non lobulata," by the presence of "haustoria lobulata." De Bary made the following observations on *E. galeopsidis*: "Diese Form unterscheidet sich von der vorigen (*E. lamprocarpa*) durch die gelappten Haustorien-Anhängsel, sie ist sonst der auf *Plantago* und Borragineen wachsenden *lamprocarpa* sehr ähnlich. Eine Haupteigenthümlichkeit, wegen deren ich sie, zur Zeit weingstens, von allen anderen Formen trennen muss, ist die, dass sie nicht wie letztere noch auf dem lebenden Pflanzentheil Sporen in ihren Ascis bildet, sondern hier immer ohne Sporen vorkommt."

All subsequent authors have followed De Bary in maintaining *E. galeopsidis* as a distinct species, and have relied on the lobed haustoria and absence of spores in the ascus as separative characters from *E. cichoraccarum*. Most authors state that the spores (two in number) are produced in the following year, and that the

species is confined to certain host plants belonging to the Labiatae. In the size, etc., of the perithecia, nature of appendages, number and size of asci, etc., there is no difference—as indeed is generally admitted—between *E. galeopsidis* and *E. cichoracearum*, so that the claim of the former to rank as a distinct species rests on two supposed separative characters, viz.: the lobed haustoria and the non-development of spores on the living host-plant.

This latter peculiarity is found also as a rule in *E. graminis*, but we must notice that in this species spores are sometimes produced in late summer or autumn, so that in *E. graminis*, at least, it is seen that this character is not one of specific importance.

So long, however, as the absence of spores and the presence of lobed haustoria could be considered as correlated characters, and ones not occurring in *E. cichoracearum*, *E. galeopsidis* could be maintained as a distinct species. Some cases I have examined, however, make me doubt if we can consider either of these characters as absolutely characteristic of *E. galeopsidis*. In the examination of a large amount of material I have certainly found that the *Erysiphe* on species of *Lamium*, *Galeopsis*, *Stachys*, etc., invariably contain asci without any trace of spores, and in all cases where examination was made the mycelium was found to possess lobed haustoria. But, on the other hand, as regards this character of the non-production of spores, there are forms of *E. cichoracearum* which appear to be connecting links. Such are the forms on *Mentha arvensis*, *M. aquatica*, *Lycopus Europaeus* and *Scutellaria lateriflora*. On these host-plants, some specimens of the fungus, apparently mature, have perithecia in which the asci show no trace of spores, and are in fact indistinguishable, as regards perithecia, from *E. galeopsidis;* in other specimens two more or less well-formed spores are found in the ascus. The haustoria of the fungus on these hosts are not lobed (although there is sometimes a tendency for them to have a crenulate margin), and for this reason, probably, De Bary placed the fungus on *Mentha* and *Lycopus* under *E. cichoracearum*. The fungus on *Scutellaria* very rarely shows any signs of the formation of spores in the ascus, and it is probably on this account that Burrill places it under *E. galeopsidis;* the haustoria, however, are not definitely lobed. Another striking case is that afforded by the fungus on species of

Galium. Curiously enough, this form in Europe has been referred by all botanists to *E. communis* (*E. polygoni*), although it undoubtedly belongs to *E. circhoracearum*, of which it appears to be a form approaching *E. galeopsidis*. In all the European specimens I have examined the perithecia have contained asci without any trace of spores, and the habit, size, shape and number of asci, etc., further show that the fungus does not belong to *E. polygoni*. Moreover, in Turkestan specimens on *Galium boreale* and other species of the genus, and in American ones on *Galium aparine* and *G. triflorum* the asci are regularly bisporous with apparently ripe spores. For this reason American mycologists have placed the form under *E. cichoracearum*. The shape of the haustoria in the form on *Galium* appears also variable. These, although small, and in this respect very unlike those of *E. galeopsidis*, are sometimes, although rarely, distinctly lobed; in other specimens they resemble those of *E. cichoracearum*. It appears, therefore, from the above cases, that *E. cichoracearum* is sometimes similar to *E. galeopsidis* in not producing spores on the living host-plant.

The difference in the size and shape of the haustoria in *E. cichoracearum* and *E. galeopsidis* is, as a rule, striking. The haustoria of the former species (examples on about thirty different host-plants were examined) are small and simple, those of the latter are much larger, much lobed irregularly, or often more or less reniform (deeply bi-lobed) in shape. Among some American examples, however, I was surprised to find in two specimens named *E. cichoracearum* on *Eupatorium ageratoides* (one from Madison, Wisconsin, Sept., 1882, L. H. Pammel) in Professor Earle's herbarium; the other from Oregon, Illinois, Sept. 12, 1888 (in the Herbarium of the University of Illinois), haustoria of exactly the same size and shape as those on examples of *E. galeopsidis* on *Galeopsis*. Unfortunately, both these specimens are apparently rather young, and the asci contain no spores. It is, therefore, impossible to say whether we have in this case a form of *E. cichoracearum* with lobed haustoria, or whether it may not possibly be that of *E. galeopsidis*, hitherto supposed to be confined to Labiatae and *Chelone* among Scrophularineae, sometimes occurs on Compositae. In another case the fungus is undoubtedly *E. cichoracearum*. This is the specimen on *Sonchus arvensis* in Syd. Myc. March. 3051, and in

this example among simple haustoria some occur which are distinctly lobed (Fig. 131). These latter are not quite so large and certainly not so much lobed as in typical *E. galeopsidis*, but their occurrence tends to break down the distinction between the two forms.

Whilst, therefore, admitting that the form known as *E. galeopsidis* on *Galeopsis*, *Lamium*, *Stachys*, etc., is well characterized by the large, lobed haustoria and absence of spores on the living host plant, it seems that forms of *E. cichoracearum* exist in which the latter (and to some extent the former) character is found. Whether these intermediates are numerous enough to compel us to unite *E. galeopsidis* with *E. cichoracearum*, or whether the former should rank as a species, or more probably as only a variety, can only be proved by further observations, especially with regard to the haustoria of specimens of *E. cichoracearum* on its numerous host-plants. For this purpose young examples are in many cases necessary, as the mycelium is commonly evanescent in the mature condition of the fungus.

4. E. GRAMINIS DC. [Figs. 156, 159, 160]

Erysiphe graminis DC. Fl. Fr. **6**: 106. 1815; Lév. Ann. sci. nat. III. **15**: 165. *pl. 10. f. 33.* 1851; Tul. Sel. Fung. Carp. **1**: 212. 1861; Cooke, Micr. Fung. 220. *pl. 11. f. 235, 236.* 1865; Cooke, Handb. Brit. Fung. **2**: 651. 1871; Karst. Myc. Fenn. **2**: 193. 1873; Sacc. Syll. Fung. **1**: 19. 1882; Wint. in Rabenh. Krypt. Fl. Deutschl. 1^2: 30. 1884; Karst. Act. Soc. Faun. Fl. Fenn. **2**: 93. 1885; Burr. in Ell. & Everh. N. Amer. Pyren. 15. 1892; Jacz. Bull. l'Herb. Boiss. **4**: 728. 1896; Oudem. Rév. Champ. Pays-Bas. **2**: 98. 1897.

Alphitomorpha communis, var. *graminearum* Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 31. 1819; Wallr. Fl. Crypt. Germ. **2**: 758. 1833.

Erysibe communis, var. *graminum* Lk. in Willd. Sp. Pl. **6**: 106. 1824.

Erysiphe communis Fr. Syst. Myc. **3**: 239 (partim). 1829.

E. communis, var. *graminum* Duby, Bot. Gall. **2**: 869. 1830; Rabenh. Deutschl. Krypt. Fl. **1**: 232. 1844.

E. communis, var. *graminis* Dur. & Mont. Fl. d'Algér. (Crypt.) 565. 1846–9.

Erysibe communis Rabenh. Fl. Lusat. 2: 419. (partim). 1840.

E. graminis DC. Schroet.; Cohn, Krypt. Fl. Schles. 3: 240. 1893.

EXSICC.: Bri. & Cav. Fung. Par. 174; Lib. Pl. Crypt. Ard. fasc. 2, 182; Roumeg. Fung. Gall. Exsicc. 766, 1163; Syd. Myc. March. 1139, 1350, *3461, *4123; Desmaz. Pl. Cr. Fr. ed. 1 ser. 1, 1109 (B only), *ed. 2, ser. 1, 509 B; Rab. Fung. Eur. 671; Karst. Fung. Fenn. Exsicc. 677; Rab. Herb. Myc. ed. 2, 473, 759; de Thüm. Fung. Austr. 1244; de Thüm. Myc. univ. 257; Fckl. Fung. Rhen. 659; Westend. Herb. Crypt. Belg. 554; Vize, Fung. Brit. 143; Klotzsch, Herb. Myc. 62; Jack, Lein. & Stizenb. Krypt. Bad. 829; Ayres, Brit. Fung. 23; Ell. & Everh. N. Amer. Fungi, 2813; Erb. Critt. Ital. ser. 1, 286 (in Herb. Mus. Florence); *Ell. & Everh. Fung. Columb. 505; *Erikss. Fung. par. scand. exsicc. 238; *Seym. & Earle, Econ. Fung. 96.

Usually epiphyllous, but sometimes amphigenous; mycelium more or less persistent, effused or forming scattered patches, at first white, frequently becoming pale brown or gray; perithecia large, 135–280 μ in diameter, usually about 200 μ, scattered or gregarious, globose-depressed, becoming concave, usually more or less immersed in the lanuginose persistent mycelium, which is formed of sparingly branched, curved, rather rigid thick-walled or solid, shining, interlaced hyphae, 4–5 μ wide, cells of perithecium obscure; appendages rudimentary, few or numerous, very short, simple or sparingly branched, pale brown; asci numerous, 9–30, usually from 15–20, varying from cylindrical to ovate-oblong, more or less longly pedicellate, 70–108 × 25–40 μ; spores 8 (or rarely 4), 20–23 × 10–13 μ, seldom produced on the living host-plant.

HOSTS.—*Agropyron caninum* (319), *A. glaucum*, *A. repens*, *A. scabrum*, *A. tenerum* (151), *Agrostis alba* (263), *A. exarata* (60), *Alopecurus agrestis* (56), *Apera Spica-Venti*, *Arrhenatherum avenaceum* (370), *Avena fatua* (66), *A. sativa*, *Beckmannia erucaeformis*, *Bromus asper* (319), *B. breviaristatus*, *B. madritensis* (16), *B. mollis* (3) (132) (224) (229) (319) (399), *B. rubens*, *B. secalinus* (319), *B. sterilis*, *B. tectorum* (399), *B. unioloides* (60) (151), *Dactylis glomerata*, *Deschampsia caespitosa* (319), *Elymus condensatus* (363), *Festuca arundinacea* (176), *F. elatior*, *F. gigantea* ( ), *F. heterophylla* (319), *Glyceria aquatica* (6), *G. nervata* (6), *Holcus*

mollis (319), *Hordeum jubatum* (6), *H. murinum* (272), *H. secalinum*, *H. vulgare*, *Lolium perenne* (107), *Milium effusum* (319), *Panicum sanguinale* (60), *Phleum pratense* (345), *Poa annua*, *P. Buckleyana*, *P. bulbosa*, *P. nemoralis*, *P. pratensis*, *P. serotina*, *P. sinaica* (233), *P. tenuifolia*, *P. trivialis*, *Saccharum officinarum* (143), *Secale cereale* (22) (69) (399), *Sesleria caerulea* (107), *Triticum sativum*, *T. Spelta*, *T. vulgare*.

Distribution.—EUROPE: Britain, France, Spanish Peninsula (101), Belgium, Switzerland (176), Italy, Germany, Austria-Hungary, Denmark, Norway, Sweden, Finland, Russia.

AFRICA: Algeria.

ASIA: Cyprus, Transcaucasia (338), Persia (233), Turkestan (Seravschan) (206), Siberia (235) (348), Japan.

AUSTRALIA: Thistle Island, Victoria and New South Wales (225).

NORTH AMERICA: United States—Massachusetts, New York, Pennsylvania, West Virginia (249), South Carolina (35), Michigan, Illinois, Mississippi (361), Iowa (165), South Dakota, Kansas, Montana, Idaho, Wyoming, Colorado, Nevada (363), California, Washington; Canada—Newfoundland, Ontario.

A very distinct species in the large size of the perithecium, and the large, usually numerous, asci. In these characters it somewhat recalls *E. taurica*, which differs, however, in the constantly bisporous asci. In *E. graminis* the asci usually show no trace of spores, being filled merely with granular protoplasm. When the spores are produced they are eight in number; according to Wolff, however, sometimes the number is only four. In Europe, *E. graminis*, as a general rule, is characterized by this absence of ascospores on the living host plant, and in the numerous material examined only two cases have occurred in which any signs of their production were observable. Among the twenty four examples of *E. graminis* in European exsiccati, mentioned above, only one (Rab. Fung. Eur. no. 671) showed spores in the ascus. This specimen was gathered on *Triticum sativum* in August; two of the asci, each containing 8 spores, are represented at Fig. 159. The other specimen (in the Herbarium of the Florence Museum) is on *Bromus sterilis*, and was collected in October. Here eight very young spores were seen in some of the asci. In the United

States, however, the development of ascospores in autumn, or even late summer, appears to be not uncommon. Anderson (6) mentions that ripe ascospores have been found on a species of *Poa* in Missouri in July, on *Beckmannia erucaeformis* and *Hordeum jubatum* in October, and on *Poa tenuifolia* in November, or usually by the middle of October. In a specimen on *Poa nemoralis*, gathered by Griffiths & Carter in South Dakota in August, I have found 8 well-formed spores in the ascus.

A very interesting account is given by Wolff (399) of the development and germination of the ascopores. This author found that if perithecia of *E. graminis* containing asci in which no spores are yet formed are placed in water (damp atmosphere, or even a position on water was found to produce no result) they showed, after two or three days, a change in the protoplasmic contents of the asci, leading up gradually, in the course of five or six days, to the formation of usually eight, or seldom only four, spores. These ascospores, like the conidia, were found to germinate readily in a damp atmosphere or in a drop of water. In dry air, however, at a temperature of 22°, they perished after 1 or 1½ hours. Under favorable conditions each ascospore was found to produce several germinating tubes, which at most reached to twice the diameter of the spore and which perished if after a period of 30 hours at the longest they failed to reach the epidermis of a suitable host-plant. If, however, this was reached the hyphae penetrated it and proceeded to form a mycelium in the same manner as those of a germinating conidium, *i. e.*, by first forming a haustorium, and then spreading from this center. It may be noted that Wolff tried to infect grasses with *E. communis* (*E. polygoni*), and conversely the host plants of *E. polygoni* (*Trifolium*, *Lupinus*, etc.) with *E. graminis*, but without success in either case.

The perithecia of *E. graminis*, when carefully isolated from the persistent mycelium are seen to possess only very short rudimentary appendages ; a few surrounding hyphae of the persistent mycelium often adhere to the perithecia when the latter are taken out, and these hyphae have apparently been mistaken by many authors for true appendages.

Garovaglio and Cattaneo (143) give an interesting account of the manner in which *E. graminis* attacks wheat. These authors

were unable to find any spores in the asci of perithecia occurring on living host-plants, but by placing leaves bearing perithecia in water, and leaving them in this position for some days under a bell jar, they were able to induce the formation of spores (8 in each ascus). *E. graminis* occasionally causes serious damage to forage and cereal crops, especially to wheat. It is stated in the Jour. Roy. Agric. Soc. England, for 1898 (184), that the fungus "appears to be greatly encouraged in wheat that is growing luxuriantly from an abundance of nitrogenous manure. . . . Sprinkling with flowers of sulphur may be useful if applied in the early stages of the attack." Outbreaks of the disease to a serious degree have been reported on the continent, occurring especially on winter-sown cereal crops; sulphur has been employed with success (see 188, 189, 191 and 400). Anderson (4), speaking of the attacks of *E. graminis* in Montana, U. S. A., says: "it affects chiefly the *Poas*, and is especially damaging to *P. tenuifolia*, one of our most valued forage grasses."

Oidium monilioides Desm. is the conidial stage of the present species.

The record of "*E. graminis*" on *Circaea Lutetiana* in Lamb. Fl. Myc. Belg. 2, 188, is evidently an error for *E. polygoni*.

Burrill (60, p. 15) concludes his description of *E. graminis* with the following remark: "Anderson says there are sometimes as many as 20 sporidia in an ascus—a variation not reported elsewhere." I cannot help thinking that "20 asci in a perithecium" was originally intended.

5. E. TORTILIS (Wallr.) Fr.

Alphitomorpha tortilis Wallr. Berl. Ges. Nat. Freund. Verh. **1**: 35. 1819; Wallr. Fl. Crypt. Germ. **2**: 756. 1833.

A. corni Wallr. Ann. Wett. Ges. **4**: 244. 1819.

Erysibe tortilis Lk. Willd. Sp. Pl. **6**: 111. 1824; Rabenh. Deutschl. Krypt. Fl. **1**: 231. 1844; Schroet. in Cohn's Krypt. Fl. Schles. **3**: 241. 1893.

Erysiphe tortilis Fr. Syst. Myc. **3**: 243. 1829; Berk. Sm.-Eng. Fl. **5**: 327. 1836; Lév. Ann. sci. nat. III. **15**: 170. *pl. 11. f. 35.* 1851; Tul. Sel. Fung. Carp. **1**: 213. *pl. 5. f. 8.* 1861; Cooke, Micr. Fung. 221. *pl. 12. ff. 245, 246.* 1865; de

Bary, Beitr. Morph. Phys. Pilz. 1: § XIII. 51. 1870. Cooke, Handb. Brit. Fung. 2: 651. 1871; Sacc. Syll. Fung. 1: 17. 1882; Wint. Rabenh. Krypt. Fl. Deutschl. 1^2: 32. 1884; Jacz. Bull. l'Herb. Boiss. 4: 729. 1896; Oudem. Rév. Champ. Pays.-Bas. 2: 95. 1897.

E. corni Duby, Bot. Gall. 2: 870. 1830; Cast. Cat. Pl. Mars. 191. 1845.

EXSICC.: Rab. Fung. Eur. 672, 1521, 2033; Syd. Myc. March. 197, 1637; Desmaz. Pl. Cr. Fr. ser. 1, 266, * ed. 2, ser. 1, 815; Cooke, Fung. Brit. Exsicc. 98, ed. sec. 286; Vize, Fung. Brit. 97; Rehm, Ascom. 548; Berk. Brit. Fung. 204; Oudem. Fung. Neerl. Exsicc. 161; Roumeg. Fung. Gall. Exsicc. 974; Fckl. Fung. Rhen. 672; de Thüm. Fung. austr. 134; Sacc. Myc. Ven. 601; Rab. Herb. Myc. ed. 2, 472; de Thüm. Myc. univ. 258; Kunze, Fung. Select. exsicc. 61, 577; Westend. Herb. Crypt. Belg. 552; Vestergr. Microm. rar. select. 103; Erb. Critt. Ital. ser. 2, 986 (Herb. Mus. Florence); * Krieg. Fung. Saxon. 724; * Wartm. & Schenk, Schweiz. Krypt. 425.

Hypophyllous, very rarely epiphyllous; mycelium arachnoid, effused, evanescent, or very slightly subpersistent in scattered patches; perithecia densely gregarious to scattered, subglobose, 65–110 μ in diameter, cells distinct, 10–20 μ wide, usually over 15 μ, appendages well developed, very long, 10–20 times the diameter of the perithecium, 8–20 or more in number, 4–5 μ wide, brown, paler above, septate, flexuose, assurgent and fasciculate above, flaccid; asci 2–5, usually 4, broadly ovate to subglobose, with or without a stalk, 50–60 × 36–45 μ; spores 4–8, usually 8, 20–24 × 10–14 μ.

Hosts.—*Cornus alba* (3) (263), *C. sanguinea.*

Distribution.—EUROPE: Britain, France, Belgium, Netherlands, Switzerland, Italy, Germany, Austria-Hungary, Denmark, Sweden, Russia.

Distinct in the genus in the possession of the always long, well-developed appendages, assurgent and fasciculate above after the manner of some species of *Microsphaera.*

E. tortilis is frequently recorded (*e. g.*, by Bessey (40, p. 13), Trelease (366, p. 9), Rose (299)) from the United States on *Clematis Virginiana*, but the numerous specimens I have seen so named all belong to *E. polygoni*, and it seems very probable that

E. tortilis is confined to Europe. Burrill (60) records the present species as occurring in the United States, remarking as follows: "On *Cornus sanguinea*, Missouri (Tracy and Galloway). This is here included solely upon the authority given, and apparently upon one collection. In Europe the fungus is common on the same host, and as this is abundant in cultivation with us, it is altogether probable that this parasite may be frequently found."

It may be noticed that certain forms of *E. polygoni* (especially those on *Clematis*) are very similar to *E. tortilis* when examined under the microscope with the appendages flattened horizontally by the pressure of a cover-glass; when examined *in situ* on the leaf, however, it is seen that in *E. tortilis* the appendages are assurgent, altogether free from the surface of the leaf, and fasciculately wound together, while those of the form of *E. polygoni* in question spread horizontally on the leaf.

E. tortilis is sometimes recorded on *Cornus Mas*, but all the specimens so named that I have seen have proved to be *Phyllactinia corylea*. The record by Bagnis (18) of the occurrence of the present species on *Bellis annua* requires confirmation.

It is possible that the earliest specific name for this species is *corni*, given by Wallroth in the Ann. Wett. Ges., in 1819. The name *tortilis*, given by the same author in the Verhandl. Berl. Gesell. Nat. Freund., dates from the same year, and there appears to be no evidence as to which work appeared first. Under these circumstances, I have used the name *tortilis*, as being the one in general use, and as that retained by Wallroth himself in his later work, Flora Crypt. Germaniae.

6. E. TAURICA Lév. [Figs. 145–150, 152–154]

Erysiphe compositarum Duby, Bot. Gall. **2**: 870 (partim). 1830.

E. taurica Lév. Démidoff's Voy. Russ. mérid. (bot.) 119. *pl. 6. f. 5.* 1842; Dur. & Mont. Fl. d'Algér. (Crypt.) 566. 1846–9; Lév. Ann. sci. nat. III. **15**: 161. *pl. 10. f. 30.* 1851; Sacc. Syll. Fung. **1**: 16. 1882.

Erysibe depressa Rabenh. Deutschl. Krypt. Fl. **1**: 232 (partim). 1844.

Erisyphe picridis Cast. Cat. Pl. Mars. 192. 1845.

E. lappae Cast. Cat. Pl. Mars. 192. 1845.

E. Duriaei Lév. Ann. sci. nat. III. **15**: 165. *pl. 10. f. 32.* 1851; Sacc. Syll. Fung. **1**: 17. 1882.

E. lanuginosa Fckl. Bot. Zeit. 27. 1871; Sacc. Syll. Fung. **1**: 20. 1882.

E. Saxaouli Sorok. Rev. Myc. 146. *pl. 89* (15). *f. 231–236.* 1889; Sacc. Syll. Fung. **9**: 370. 1891.

E. armata Sorok. Rev. Myc. 146. *pl. 88* (13). *f. 195–203.* 1889; Sacc. Syll. Fung. **9**: 370. 1891.

E. alhagi Sorok. Rev. Myc. 147. *pl. 89* (15). *f. 237–239.* 1889; Sacc. Syll. Fung. **9**: 371. 1891.

E. pegani Sorok. Rev. Myc. 148. *pl. 91* (16). *f. 248–251.* 1889; Sacc. Syll. Fung. **9**: 371. 1891.

E. lichenoides Trab. & Sacc.; Sacc. Syll. Fung. **11**: 253. 1895.

E. papilionaccarum Kom. Scripta Bot. Hort. Univ. Imp. Petropol. **4**: 271. 1895.

E. lanata P. Magn. Verh. k. k. zoöl.-bot. Gesell. Wien, **49**: 100. *pl. 3. f. 20–22.* 1899.

Microsphaera Bornmuelleriana P. Magn. Verh. k. k. zoöl.-bot. Gesell. Wien, **49**: 100. *pl. 3. f. 23–25.* 1899.

EXSICC.: Roumeg. Fung. Select. Exsicc. 6017; Rab. Fung. Eur. 1520; and 1735 sub *E. communis;* Sacc. Myc. Ven. 1169 sub *E. lamprocarpa;* Syd. Myc. March. 1076; and 1351 sub *E. cichoraccarum;* de Thüm. Myc. Univ. 2153 sub *E. lamprocarpa;* Erb. Critt. Ital. ser. 2, 145 sub *E. communis;* and 445 sub *E. Montagnei* (in Herb. Mus. Florence).

Amphigenous, often covering the whole plant; mycelium usually persistent, effused, densely compacted, tomentose-membranaceous, or crustaceous, usually white, rarely pale buff in places, sometimes, however, wholly evanescent; perithecia scattered or gregarious, usually more or less immersed in the persistent mycelium, large, 135–240 μ in diameter, usually about 200 μ, soon becoming concave, cells obscure; appendages usually very numerous, densely interwoven, rather short, more or less vaguely branched, colorless or brown, sometimes very short or even obsolete; asci 7–38, usually about 20, large, from narrowly cylindrical to ovate, usually longly pedicellate, 75–110 (usually about 90) × 28–40 μ; spores 2, large, variable in size, usually about 32 × 18 μ, but varying from 28–40 × 14–22 μ, sometimes slightly curved.

HOSTS.—*Acanthophyllum glandulosum, Alhagi camelorum* (206), *A. maurorum, Althaea ficifolia, A. kurdica, Arctium minus, Artemisia Dracunculus, Astragalus* sp., *Capparis spinosa, Carduus crispus* (132), *Carlina corymbosa, C. lanata, Carthamus lanatus, Carinthe major* (214), *Chondrilla juncea, Cicer songaricum* (206), *Clematis songarica, Cnicus arvensis* (214), *C. cardunculus, C. lanceolatus* (55) (132), *Coccinea dubia* (206), *Cynara cardunculus, Daucus maximus, Diarthron vesiculosum* (206), *Dorycinum herbaceum* (214), *Elaeoselinum Lagascae, Eryngium campestre, E. Noëanum* (233), *Euphorbia lanata, Exochorda Alberti* (19), *Foeniculum vulgare, Gundelia Tournefortii, Haloxylon ammodendron, Haplophyllum Sieversianum* (206), *Hedysarum Falconeri, Helianthemum oelandicum, Inula nervosa, Nepeta podostachys, Odontospermum aquaticum, Peganum Hamala, Phlomis Herba-venti, P. tuberosa* (214), *Picris hieracioides, Psoralea drupacea, Salsola canescens* (233), *Saussurea* (214), *Scutellaria multicaulis, Taraxacum montanum, Teucrium chamaedrys, Thevenotia scabra* (233), *Thymelaea* sp., *Verbascum Blattaria, V. phlomoides, V. speciosum, Vicia tenuifolia, Zygophyllum Fabago.*

Distribution.—EUROPE: France, Spain, Italy, Greece, Germany, Austria-Hungary, Russia.

AFRICA: Algeria.

ASIA: Turkey, Syria, Persia, Turkestan, India.

E. taurica has been much confused with both *E. cichoracearum* and *E. polygoni.* From the latter species the very numerous regularly bisporous asci at once distinguish it. From the former it is known by the large size of the asci and spores, and from both by the very large concave or "pezizoid" perithecia. The latter feature, indeed, is so characteristic that it makes *E. taurica* one of the few species of the Erysiphaceae which can be safely determined with the lens.

I am quite convinced that *E. Duriaei* Lév., *E. lanuginosa* Fckl., *E. lichenoides* Trab., and *E. papilionacearum* Kom., all belong to the present species. *E. Duriaei* (on species of *Phlomis*) and *E. papilionacearum* (on *Astragalus, Psoralea* and *Cicer*) have been stated to differ from *E. taurica* in having colored appendages; the former, also, in possessing only 8 asci. These characters do not hold good. There is a specimen of *E. Duriaei* in the Kew Her-

barium from Léveillé's herbarium, labelled "Gallia austral. ad fol. *Phlomidis herba-venti*," which is apparently the specimen referred to by Léveillé in his monograph. In this specimen the perithecium contains up to 30 asci. In authentic specimens of *E. papilionacearum*, as well as in the example of *E. Duriaei* mentioned above, the appendages are sometimes colorless, sometimes pale brown, and we find just the same variation in these characters in authentic specimens of *E. taurica* on other hosts. Both plants must be undoubtedly referred to *E. taurica*, and it may be noticed that Komarow (206, p. 39) although giving *E. papilionacearum* specific rank, speaks of the plant as forming a passage from *taurica* to *Duriaei*. *E. lanuginosa*, on *Daucus maximus* from Greece, was originally described by Fuckel as "8–12-spored," and this description has been copied by subsequent authors. Examination of authentic specimens shows however that the asci are constantly bisporous, and the plant, together with that on *Foeniculum vulgare* from Algeria, described by Trabut and Saccardo as *E. lichenoides*, present no distinguishing characters from *E. taurica*.

In the Revue Mycologique for 1889 Sorokine published the following new species of *Erysiphe* from Central Asia (Turkestan); *E. Saxaouli* on *Haloxylon Ammodendron*, *E. armata* on *Malva* sp.; *E. alhagi* on *Alhagi camelorum*, and *E. pegani* on *Peganum Hamala*. I have not been able to see authentic specimens of these plants, but from the descriptions and figures given by Sorokine, I have little hesitation in referring them all to *E. taurica*. I have seen an *Erysiphe* (representing probably *E. pegani* and *E. Saxaouli*) on *Peganum Hamala* and *Haloxylon Ammodendron* from Turkestan, which is certainly *E. taurica*; as regards *E. alhagi* Komarow reports *E. taurica* on *Alhagi camelorum*. Komarow (206, p. 275), who has collected since in the same region as Sorokine did, has already expressed the opinion that these three species were founded on immature examples of *E. taurica*.

Since the above notes were written, Magnus (233) has published as new species, under the names of *Erysiphe lanata* and *Microsphaera Bornmuelleriana*, two plants occurring respectively on *Euphorbia lanata* and *Acanthophyllum glandulosum*, collected by Bornmüller in Persia. Both these plants I refer to *E. taurica*.

E. lanata is thus described: "Diese schöne *Erysiphe* bildet

einen dichten weissen filzigen Mehlthau auf der *Euphorbia lanata* Sieb. Die Perithecien haben 120–150 μ Durchmesser; sie haben nur an der Basis ganz kurze, flockige, hyaline Appendiculae von der Länge etwa eines Drittels des Durchmessers der Perithecien; diese enthalten sehr zahlreiche Asci, 20 und mehr. Der Ascus enthält drei oder vier oder auch fünf Sporen (mehr habe ich nicht gesehen, könnten aber recht wohl auftreten). Die Ascosporen sind oval, 27 μ lang und 13.5 μ breit."

I am indebted to Professor Magnus for kindly sending me the type specimens of *E. lanata* and *M. Bornmuelleriana* for examination.

The size of the perithecia of *E. lanata* is somewhat larger than that given in the description, as in mature examples it is usually 190–210 μ. The asci, also, appear to be constantly bisporous. In some of the unripe asci there are, besides the two young spores, one or two drops of oily matter; in the ripe ascus, however, only 2 large spores were observed. If more than 2 spores do occur, it is certainly only very rarely; and in the habit, large perithecia, with very numerous large asci the plant on *Euphorbia lanata* agrees perfectly with *E. taurica*. On looking over the specimens of *Euphorbia lanata* in the Kew Phanerogamic Herbarium, I found plants, on three sheets, more or less covered with the present fungus. The first plant came from Persia, "prov. Tarsistan, ad. Persepolis, c. 1600 m. s. m." (Bornmüller, Iter Persico-turcicum 1892–3, 4675); the two others from Syria, one labelled "Reliquiae Mailleanae no. 1675"; the other collected by Sir J. D. Hooker and Mr. D. Hanbury in 1860. There is also a fungus in the Kew Herbarium labelled "*S. Castagnei* ad. *Euphorb.* sp. nr. Kellal, 10,000 Pers. austr. (Prof. C. Haussknect, Iter orientale, 1868)." This proves on examination to be *E. taurica*, and is apparently the same plant as that to which Magnus (233, p. 100) refers.

M. Bornmuelleriana is thus described: "Diese schöne *Microsphaera* ist durch den Charakter ihrer Appendiculae sehr ausgezeichnet. Der Durchmesser der Perithecium schwankt von 147–231 μ, ist durchschnittlich 197 μ. Sie sind an ihrer Basis von einem dichteren Kranze von Appendiculae umgeben, deren Höhe etwa die den Durchmesser der Perithecien erreicht. Die Appendiculae sind in

der für *Microsphaera* charakteristischen Weise zwei bis drei Male dichotom oder trichotom getheilt und ihre letzten Enden sind zart und lang schlauchförmig verlängert, wie das auch bei der nordamerikanischen *Microsphaera Van-Bruntiana* Ger. auf *Sambucus Canadensis* der Fall ist. Während aber bei allen anderen *Microsphaera*-Arten, die ich kenne, die Appendiculae einzeln frei von einander vom Perithecien abstehen, verflechten sie sich hier zu einem dichten Filze mit einander, der die Basis des Peritheciums umgibt und die Perithecien etwa emporhebt. Während sonst die Verzweigungen der wiederholt dichotom getheilten Appendiculae von *Microsphaera* starr sind, bleiben eben hier die langen schlauchförmigen Endzweige der Appendiculae zart und hyalin, und verflecten sich etwas gekräuselt durch einander. Die Perithecien enthalten zahlreiche Asci. Im Ascus wurden 4–6 Sporen beobachtet, manchmal in einem Ascus zwei grosse und zwei kleine, offenbar abortirende Sporen. Die Ascosporen sind oval, etwa 30 μ lang und 19 μ breit."

This plant is certainly not a *Microsphaera*, but belongs to *Erysiphe*, and in my opinion cannot be separated from *E. taurica*. It has no points of resemblance whatever with *Microsphaera Van-Bruntiana* (*M. grossulariae*). The branching of the much-interwoven appendages is quite vague and ill-defined, and similar to that found in *E. taurica* on other hosts. Even in "*M. Bornmuelleriana*" the appendages are not by any means always 2–3 times di-trichotomous, but are frequently only once or twice vaguely branched (see Figs. 145, 146, 147). Just the same kind of vague branching is found in some appendages of "*E. lanata*" on *Euphorbia* (see Fig. 148). Further, in all the perithecia which I have examined, the asci are bisporous, and the whole habit of the plant, the large "pezizoid" perithecia, large asci and spores, etc., are quite characteristic of *E. taurica*.

Erysiphe intertexta Berk. mss. in Herb. Kew on *Capparis* sp., "between Lama Yara and the Phatu Pass, 1848, Dr. Thomson," is *E. taurica*.

In mycelial characters *E. taurica* is extremely variable, and there is no doubt that it is partly due to this fact that the species has been described under so many different names. When persistent, the mycelium varies from felted tomentose to crustaceous

or lichenoid; its color is usually white, but sometimes (as on *Capparis herbacea*, *Clematis songarica*) it shows here and there patches of a pale buff color, at these spots the mycelium somewhat resembles thin washleather. Sometimes, however, the mycelium is completely evanescent, as Léveillé, indeed, pointed out in 1851. We sometimes find on a plant whose leaves are for the most part entirely covered with densely compacted persistent mycelium, some leaves here and there on which there is no trace of mycelium, the perithecia occurring quite naked on their surface; also on some plants which have a dense covering of stellate hairs on the leaves (*e. g.*, *Verbascum Blattaria*, *V. phlomoides*, *Phlomis Herba-venti*) the mycelium is apparently never persistent.

The persistent mycelium and large subimmersed perithecia give to *E. graminis* an external resemblance to the present species, but *E. taurica* is most closely allied to *E. cichoracearum*; indeed, occasionally certain forms of the latter species on *Arctium* show a slight approach towards *E. taurica*.

Komarow (206, p. 277) notes that in Seravschan (Turkestan) at the height of 6,000 feet *E. taurica* is one of the most widely-spread species, up to 4,000–5,000 feet, occurring on almost all the plants of the steppes, but that higher than 6,000 feet the fungus does not occur, although several of its hosts ascend to a higher altitude.

E. taurica has been reported from Asiatic Siberia on *Achillea Ptarmica*, but the specimens I have seen from there all belong to *E. cichoracearum*. Léveillé (214, p. 162) gives *Cnicus eriophorus* as a host-plant for *E. taurica*, but a specimen so named in Léveillé's handwriting in Montagne's herbarium, on this host, is *E. cichoracearum*.

The conidia of *E. taurica* are very large; in examples on *Euphorbia* and *Acanthophyllum* they frequently measure 50 × 18 μ.

7. E. AGGREGATA (Peck) Farl. [Fig. 144].

Erysiphella aggregata Peck, Reg. Rep. **28**: 63. *pl. 2. f. 1–3.* 1875; Sacc. Syll. Fung. **1**: 23. 1882.

Erysiphe aggregata (Peck) Farl. Bull. Buss. Instit. **2**: 227. 1878; Burr. Ell. and Everh. N. Amer. Pyren. 14. 1892.

EXSICC. Seym. & Earle, Econ. Fung. 168; de Thuem. Myc.

Univ. 753, 754, *Ell. & Everh. Fung. Columb. 222; Ell. & Everh. N. Amer. Fung. 2763.

Amphigenous; mycelium evanescent or here and there persistent, at first white becoming yellowish, perithecia more or less densely gregarious, sometimes very crowded and forming a crust-like covering, globose-depressed, variable in size, 130–230 μ in diameter, usually about 180 μ; cells 10–15 μ wide, usually 10 μ, often obscure; appendages numerous, densely interwoven, from equaling to 2–4 times exceeding the diameter of the perithecium, colorless or rarely pale yellowish-brown in the lower half, more or less branched, irregularly swollen and bent at intervals, at first thin-walled and septate, becoming thick-walled towards base; asci numerous, usually about 20, but sometimes as many as 42, from ovate-oblong to more or less cylindrical, large, 80–115 × 30–40 μ; spores 8, rarely 7, very rarely 6, somewhat roundish, 16–20 × 10–15 μ, usually about 18 × 12 μ.

Host.—On female catkins of alder; *Alnus incana*, *A. serrulata*, *A. viridis*.

Distribution.—NORTH AMERICA: United States—New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Canada, New Brunswick, Ontario.

Peck (279, p. 63) originally published the present species as the type of a new genus, with the following description: "*Erysiphella* nov. gen., perithecia destitute of appendages, spores definite. This genus differs from *Perisporium* in having a definite number of spores in an ascus, and from *Uncinula*, *Microsphaera* and *Erysiphe* in being destitute of appendages."

The present species really possesses, however, as Farlow (123) has already pointed out, very numerous appendages, and is certainly to be referred to the genus *Erysiphe*. The appendages are more or less densely interwoven, forming usually a pulvinate mass at the base of the perithecium, and are somewhat easily broken off, so that often on quite old perithecia only the broken ends are to be found, or sometimes even these are not to be seen.

Although distinct in its curious habitat on the female catkins of alders, *E. aggregata* morphologically must be considered very close to *E. polygoni*, from which it differs only in the large perithecia, and larger, more numerous, subcylindrical asci. The eight roundish spores give a characteristic appearance at first sight to *E. aggregata*, but just the same shaped spores are found in the in-

teresting form (occurring on young twigs of *Alnus incana* in Finland) published as a distinct species, *E. vernalis*, by Karsten, but which I have felt compelled to regard as only a form of *E. polygoni*. *E. aggregata* can be separated from this form on the twigs of *Alnus* in Europe only by the larger average size of the perithecia and asci, and the greater number of the latter—characters of not very high specific importance. It is quite possible, I think, that *E. aggregata* may have to be considered only a well-marked variety of *E. polygoni*, rather than a distinct species. Valuable evidence on this point might perhaps be obtainable from the experiment of sowing conidia of *E. aggregata* on host plants of *E. polygoni*, or conversely by infecting alder catkins with the conidia of *E. polygoni*.

8. E. TRINA Harkn. [Figs. 141, 142]

Erysiphe (*Erysiphella*) *trina* Harkn. Bull. Calif. Acad. Sci. 1: 41. 1886; Sacc. Syll. Fung. Addit. ad Vol. I.–IV.: 3. 1886; 9: 370. 1891; Burr. in Ell. & Everh. N. Amer Pyren. 14. 1892.

EXSICC.: Ell. & Everh. N. Amer. Fung. 2337; * Ell. & Everh. Fung. Columb. 23.

Epiphyllous; mycelium persistent, effused or forming irregular patches; perithecia minute, at first yellow, becoming yellowish-brown, globose, more or less gregarious, small, 52–60 μ in diameter, averaging 55 μ, cells at first evident, 8–10 μ wide, soon becoming indistinct as the wall becomes semi-transparent; appendages usually 3 or 4, short and very rudimentary, sometimes apparently absent; asci 3, very rarely 2, brodly ovate to subglobose, with or without a minute stalk, 48–50 × 28–36 μ; spores 2, large, sometimes slightly curved, 25–34 × 14–16 μ.

Host.—*Quercus agrifolia.*

Distribution.—NORTH AMERICA: United States—California.

E. trina is a very marked and interesting species, only known at present from California, on the single host-plant *Quercus agrifolia*. The perithecia are very small, and yellowish-brown at maturity; the outer wall is very thin, membranaceous, and semitransparent, so that the outline of the large spores is clearly visible in the unopened perithecium (see Fig. 141). Although described as without appendages, there are usually a few rudimentary ones present at the base of the perithecium.

Sub-family PHYLLACTINIEAE Palla.

Mycelium not sending haustoria into the epidermal cells of the host plant, but forming special branches of limited growth, which pass through the stomata into the intercellular spaces of the leaf. Each of these intercellular hyphae sends a single haustorium into the cells of the surrounding tissue (spongy parenchyma).

One genus, *Phyllactinia.*

PHYLLACTINIA Lév. Ann. sci. nat. III. **15**: 144. 1851.

Perithecia large, globose-depressed to lenticular, asci many, 2- or rarely 3-spored. True appendages equatorial, rigid, acicular, with a bulbous base; apex of perithecium provided with a mass of densely crowded branched outgrowths from the epidermal cells. Etym. *φυλλον, folium,* and *ακτις, radius.* Distrib. Europe, Africa, Asia, North, South and Central America.—1 species.

Phyllactinia is known at once by the large perithecia and the rigid colorless acicular appendages with a bulbous base.

PHYLLACTINIA CORYLEA (Pers.) Karst. [Figs. 163–175]

Sclerotium Erysiphe Pers. Obs. Myc. **1**: 13 (partim). 1796.

S. Erysiphe β corylea Pers. Syn. Fung. 124. 1801; Alb. & Schwein. Consp. Fung. Lusat. 76. 1805.

S. suffultum Rebent. Prod. Fl. Neomarch. 360. *pl. 3. f. 14.* 1804.

Erysiphe coryli Hedw. f. ex DC. Fl. Fr. **2**: 272. 1805.

E. fraxini DC. Fl. Fr. **2**: 273. 1805.

Dematium Erysiphe Spreng. Fl. Hal. 387. 1806.

Erysiphe alni DC. Syn. Pl. Fl. Gall. 57. 1806; DC. Lam. Enc. Méth. (Bot.) **8**: 219. 1808; DC. Fl. Fr. **6**: 104. 1815.

E. oxyacanthae DC. Secret. Mycogr. Suisse, **3**: 655 (syn. excl. partim). 1833; Cast. Cat. Pl. Mars. 190. 1845.

E. betulae DC. Fl. Fr. **6**: 107. 1815; Duby, Bot. Gall. **2**: 870. 1830.

E. varium Fr. Obs. Myc. **1**: 206 (partim). 1815; **2**: 366 (partim). 1818.

E. varium, var. *suffultum* Fr. Obs. Myc. **1**: 206. 1815.

E. vagans Biv. Bern. Stirp. rar. Sic. man. **3**: 19. *pl. 4. f. 3.* 1815.

Erysibe pachypus Mart. Fl. Crypt. Erlang. 393. 1817.

E. suffulta (Reb.) N. v. Esenb. Syst. Pilz. Schw. 148. *pl. 14. f. 134.* 1817; Ueberbl. des Syst. 38. 1817.

Alphitomorpha guttata Wallr. Berl. Ges. Nat. Freund. Verhand. **1**: 42 (excl. syn. *E. salicis* DC.). 1819; Wallr. Ann. Wett. Ges. **4**: 245 (excl. syn. *E. salicis* DC.). 1819; Wallr. Fl. Crypt. Germ. **2**: 760. 1833.

Erysibe orbiculatus Ehrenb. N. Act. Acad. Leop. Car. Nat. Cur. **10**: 203. *pl. 12.* 1821; Lk., Willd. Sp. Pl. **6**: 115. 1824.

E. alni DC., Gray. Nat. Arr. Brit. Pl. **1**: 589. 1821.

E. guttata, var. *fagi* (Wallr.) Ficin. and Schub. Fl. Gegend. Dresd. **2**: 305. 1823.

E. guttata Lk., Willd. Sp. Pl. **6**: 116. 1824; Rabenh. Deutschl. Krypt. Fl. **1**: 234. 1844.

Erysiphe guttata Fr. Syst. Myc. **3**: 245. 1829; Duby, Bot. Gall. **2**: 871. 1830; Berk., Sm. Engl. Fl. **5**: 327. 1836; Tul. Sel. Fung. Carp. **1**: 194. *pl. 1.* 1861; de Bary, Beitr. Morphol. Phys. Pilz. 1, § XIII. 52. 1870.

E. detonsa Fr. Syst. Myc. **3**: 247. 1829.

E. mali Duby, Bot. Gall. **2**: 869. 1830.

E. fagi Duby, Bot. Gall. **2**: 871. 1830.

E. abnormis Duby, Bot. Gall. **2**: 871. 1830.

E. roboris Gachet, Act. Soc. Linn. Bord. I. **5**: 227. 1832.

Alphitomorpha lenticularis Wallr. Fl. Crypt. Germ. **2**: 759. 1833.

Erysibe coryli Wahlb. Fl. Suec. **2**: 1086. 1833.

Erysiphe lenticularis Kickx, Fl. Crypt. Env. Louv. 139. 1835.

E. quercus Mér. Rev. Fl. Par. 459. 1843.

Erysibe lenticularis Rabenh. Deutschl. Krypt. Fl. **1**: 234. 1844.

Erysiphe nivea Cast. Cat. Pl. Mars. 190. 1845.

E. pyri Cast. Cat. Pl. Mars. 190. 1845.

E. ilicis Cast. Cat. Pl. Mars. 191 (syn. excl.). 1845.

E. cerasi Cast. Cat. Pl. Mars. 191. 1845.

Erysibe lenticularis, var. *carpini* Desmaz. Ann. sci. nat. III. **3**: 361. 1845.

Erysiphe aceris Westend. Herb. Crypt. Belg. nr. 551 (cum diag.).

E. marissalii Westend. Bull. Acad. Roy. Belg. **18**: 403. *pl. 1. f. 4.* 1851.

E. guttata, var. *mespili* Cast. Supp. Cat. Pl. Mars. 53. 1851.

Phyllactinia guttata Lév. Ann. sci. nat. III. **15**: 144. *pl. 7. f. 11.* 1851; Cooke, Micr. Fung. 218. *pl. 11. f. 219, 220.* 1865; Cooke, Handb. Brit. Fung. **2**: 646. *f. 313.* 1871; Karst. Myc. Fenn. **2**: 197. 1873.

P. Candollei Lév. Ann. sci. nat. III. **15**: 150. *pl. 7. f. 12.* 1851; Sacc. Syll. Fung. **1**: 5. 1882.

P. suffulta (Reb.) Sacc. Mich. **2**: 50. 1880; Sacc. Syll. Fung. **1**: 5. 1882; Oudem. Rev. Pyren. 11. 1884; Wint., Rabenh. Krypt. Fl. Deutschl. 1^2: 42. 1884; Burr. & Earle, Bull. Ill. State Lab. Nat. Hist. **2**: 411. *f. 6.* 1887; Speg. Fung. Pat. 34. 1887; Atkins. Journ. Elisha Mitch. Soc. **7**: 68. *pl. 2.* 1891; Burr., Ell. & Everh. N. Amer. Pyren. 20. *pl. 3.* 1892; Schroet., Cohn's Krypt. Fl. Schles. **3**: 246. 1893; Jacz. Bull. l'Herb. Boiss. **4**: 736. 1896; Oudem. Rév. Champ. Pays.-Bas, **2**: 85. 1897.

P. corylea (Pers.) Karst. Act. Soc. Faun. Fl. Fenn. **2**: 92. 1885.

P. antarctica Speg. Fung. Pat. 34. 1887; Sacc. Syll. Fung. **9**: 366. 1891.

P. suffulta, var. *macrospora* Atkins. Journ. Elisha Mitch. Soc. **7**: 68. 1891.

Erysiphella Carestiana Sacc. Malpighia, **11**: 282. 1897; Sacc. Syll. Fung. **14**: 463. 1899.

Phyllactinia berberidis Palla, Bericht. Deutsch. Botan. Gesell. **17**: 65. *pl. 5.* 1899.

Exsicc. Bri. & Cav. Fung. par. 11, 170; Rab. Fung. Eur. 166, 440, 1052, 1053, 1054, 1055, 1056, 1148, 1519, 2028; Sacc. Myc. Ven. 67, 620, 621, 622, 623, 624, 625, 894, 895, 1377; Fckl. Fung. Rhen. 702, 703, 704, 705, 706, 707, 708, 709, 710, 764; de Thüm. Fung. austr. 124, 124b, 125, 126, 127, 128, 129, 445, 446, 855; Rav. Fung. Amer. exsicc. 85, 86, 623, 624; Roumeg. Fung. gall. exsicc. 1071, 1570, 2418, 2449, 2734, 3520, 3737, 4756; Cooke, Fung. Brit. Exsicc. *92, 598; ed. sec. 598; de Thüm. Myc. univ. 157, 158, 1939; and 846 sub *Microsphaera penicillata;* Oudem. Fung. Neerl. Exsicc. 162, 163; Rab. Herb. myc. ed. 2, 461, *462, 463; Lib. Pl. Crypt. Ard. fasc. 1, 82; Westend. Herb. Crypt. Belg. 413, 658, 739; Kunze, Fung. select.

exsicc. 59, 235; Desmaz. Pl. Crypt. Fr. ed. 1, ser. 1, 167, 1307, 1308, 1519, 2199, 2200, * ed. 2, ser. 1, 112; 707, 708, 1019, 1849; Syd. Myc. March. 239, 245, 433, * 3673, * 3723; Jack, Lein, u. Stizenb. Krypt. Bad. 247, 555; Rab.-Wint. Fung. Eur. 3047, 3048, 3049; Baxt. Stirp. Crypt. Oxon. fasc. 2, 96; Fl. Exsicc. Austr.-Hung. 381; Roumeg. Fung. Select. Gall. Exsicc. 260; Ell. N. Amer. Fung. 1327; Berk. Brit. Fung. 205; Moug. and Nestl. Stirp. Crypt. Vosges, 83; Vize, Fung. Brit. 92; Fl. Gall. et Germ. Exsicc. 1200; Rehm, Ascom. 797; Wint. Fung. helvet. Supp. 86, 87 (in Herb. Earle); * Seym. and Earle, Econ. Fung. 142, 143, 153, 177; * Erikss. Fung. par scand. 139a, 139b; * Kneiff. and Hartm. Pl. Crypt. Bad. 56, 162; * Funck, Crypt. Gewäch. Fichtenb. 123; * Wartm. and Schenk, Schweiz. Krypt. 14, 422, 423; Erb. Critt. Ital. ser. 1, * 191, * 594; et 591 in Herb. Mus. Florence; * ser. 2, 836, 837; * Hoppe, Fung. Epiph. 15, 16; * Wartm. and Wint. Schweiz. Krypt. 724, 823; Klotzsch, Herb. Myc. 180 (in Herb. Upsala Mus.); * Wagn. Crypt. Herb. Biel. 10; * Gandog. Fl. Alger. exsicc. 1982; * Romell. Fung. exsicc. praes. scand. 61; * Ell. and Everh. Fung. Columb. 108.

Usually hypophyllous, very rarely amphigenous; mycelium often evanescent, but sometimes more or less persistent, and then thin and effused, or rarely forming definite patches; perithecia usually scattered, but sometimes gregarious, large, globose-depressed to lenticular, 140–270 μ in diameter, or rarely reaching to 350 μ in diameter, cells rather obscure, 15–20 μ wide, apex of perithecium provided with a mass of densely crowded special outgrowths from the external cells, each outgrowth when mature terminating in a fascicled head of numerous short hyphal branches, which, when the perithecium becomes turned over, grow more or less mucilaginous and fix the perithecium upside down to the substratum; true appendages equatorial, usually from 5–18, occasionally as many as 25, 1–3 times the diameter of the perithecium, acicular, rigid, straight or occasionally slightly flexuose towards the apex, aseptate, colorless or very rarely yellowish-brown at the apex, swollen at the base into a hollow bulb; asci 5–45, subcylindrical to ovate-oblong, 60–105 × 25–40 μ, very rarely as large as 120 × 50 μ, more or less stalked; spores 2, rarely 3 (4 recorded by some authors), variable in size, sometimes curved or rather irregular in shape and larger at one end than at the other, 30–42 μ, rarely reaching to 50 μ, × 16–25 μ, when 3, smaller, about 24 × 14 μ.

Hosts.—Acer campestre (214) (263) (272) (387), *A. platanoides* (272), *A. Pseudo-Platanus, A. saccharinum* (97), *Actinidia arguta, Alnus glutinosa, A. glutinosa* × *incana, A. incana* and var. *virescens, A. maritima, A. rubra, A. serrulata, Amelanchier Canadensis, Anarthrophyllum rigidum* (336), *Angelica sylvestris, Artemisia vulgaris, Asclepias Syriaca* (280), *Berberis vulgaris, Betula alba, B. lutea* (153), *B. nana, B. nigra, B. occidentalis, B. papyracea, Broussonetia papyrifera, Buxus sempervirens* (41), *Carpinus Americana, C. Betulus, Carya* sp. (97), *Castanea dentata* (249), *C. sativa* and var. *Americana, Catalpa bignonioides, C. speciosa, Celastrus scandens, Cephalanthus occidentalis, Chelone glabra* (324), *Chionanthus Virginica* (214) *Clematis Vitalba* (130), *Colliguaja Brasiliensis* (335), *Cornus Amomum, C. candidissima* (280), *C. circinata* (280), *C. florida, C. Mas, C. Nuttallii, C. sanguinea, C. stolonifera, Corylus Americana, C. Avellana* and var. *laciniata, C. Colurna, C. rostrata, C. tubulosa, Cotoneaster* sp., *Crataegus coccinea, C. Crus-galli* (280), *C. occidentalis, C. Oxyacantha, C. rivularis, C. sanguinea* (349), *C. tomentosa* and var. *pyrifolia, Desmodium Canadense* (60), *Elsholtzia* (273), *Erythrina* sp., *Euonymus Europaeus* (22), *Fagus ferruginea* (61) (97) (280) (324), *F. sylvatica, Fragaria* sp., *Fraxinus Americana, F. excelsior* and var. *diversifolia, F. Mandshurica, F. Ornus, F. oxyphylla* (214), *F. pubescens, F. quadrangulata, F. sambucifolia, F. viridis, Hamamelis Japonica, H. Virginiana* (97) (153) (163), *Heuchera parvifolia* (6), *Hippophaë rhamnoides, Humulus Lupulus* (230), *Ilex decidua, Juglans* (130), *Liriodendron Tulipifera, Lonicera Caprifolium, L. Xylosteum, Magnolia acuminata* (280), *M. Fraseri* (249), *M. Kobus, Mercurialis perennis, Morus alba, Negundo aceroides* (151), *Nyssa* sp., *Olea Europaea* (41), *Ostrya Virginica, Paliurus aculeatus, Parmentiera alata, Paulownia imperialis, Philadelphus Lewisii, Prunus Americana* (371), *P. Avium* (214), *P. Cerasus, Pyrus amygdaliformis, P. communis, P. Germanica, P. torminalis* (214), *Quercus aquatica, Q. Catesbaei, Q. coccifera* (396), *Q. coccinea* and var. *tinctoria, Q. discolor, Q. falcata, Q. Ilex, Q. Kelloggii, Q. macrocarpa, Q. nigra, Q. palustris, Q. Phellos* (12) (371), *Q. Robur, Q. rubra, Rhamnus alpina, Rhododendron* (*Azalea*) sp., *Ribes Cynosbati, R. Grossularia, R. Magellanicum* (336), *Rubus fruticosus* (3) *Salix* sp., *S. Caprea* (214), *Sambucus* sp. (130), *S. nigra* (214) (293) (316), *Syringa vulgaris* (290),

Tanacetum vulgare, *Typha latifolia* (5), *Ulmus alata*, *U. Americana*, *U. campestris*, *U. montana*, *Vaccinium stamineum*, *Vitis Labrusca* (36), *Xanthoxylum Americanum*.

Distribution.—EUROPE: Britain, France, Portugal (396), Belgium, Netherlands, Germany, Switzerland, Italy, Austria-Hungary, Denmark, Norway, Sweden, Finland, Russia.

AFRICA: Algeria.

ASIA: Turkey (Aleppo), Transcaucasia (338), Siberia (Minussinsk) (235), China (Yun-nan) (273), Japan.

SOUTH AMERICA: Paraguay (335), Patagonia (336), Tierra del Fuego (337).

CENTRAL AMERICA: Guatemala.

NORTH AMERICA: Mexico; United States—New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, West Virginia, South Carolina, Ohio, Michigan, Indiana, Alabama, Illinois, Mississippi, Wisconsin, Missouri, Iowa, Minnesota (325), South Dakota (151), Kansas (386), Montana, Wyoming, California, Washington; Canada—Ontario, Newfoundland.

Phyllactinia corylea is the most sharply characterized and one of the most widely spread species of the Erysiphaceae. The large size of the perithecium, and the acicular appendages with a bulbous base, enable the present species to be easily recognized, usually with the naked eye.

Nevertheless, as will be seen from the synonomy, *P. corylea* has had many names given to it. This has been due partly to the fact that the appendages are either very fragile or deciduous, and so the fungus under different conditions has been supposed to belong to different species; for the most part, however, these names owe their origin to the fact that *P. corylea* grows on a very large number of hosts, and in former times the occurrence of a species of mildew on a new host-plant usually led to the description of the fungus as a new species.

There can be no doubt, when sufficient material is examined, that only a single species of *Phyllactinia* exists. Whether on its numerous hosts in America (where Burrill states that "scarcely a deciduous-leafed tree seems proof against it"), whether on *Parmentiera alata* in Guatemala, *Erythrina* in Mexico, on *Morus alba* and *Paulownia imperialis* in Japan, or on the Cupuliferae of Europe,

the variations that occur are never important enough to make us doubt that we are dealing with one cosmopolitan species, able to live not only on a great number of different trees, but also, apparently, on some herbs (see list of host-plants above).

I have united *P. Candollei* Lév., *P. antarctica* Speg., and *P. berberidis* Palla with the present species.

Léveillé described *P. Candollei* from specimens occurring on the leaves of a species of *Nyssa* in North America, and remarked (214, p. 150), "Cette espèce ressemble à la précédente [*P. corylea*]; la seule différence repose dans les sporanges, qui sont au nombre de huit et qui renferment quatre spores au lieu de deux." I have examined two specimens of Léveillé's plant; one in Berkeley's Herbarium at Kew, the other in Montagne's Herbarium in the Paris Museum; both specimens are named in Léveillé's handwriting. Many of the asci in these specimens were found to be 2-spored (in one perithecium all the asci were bisporous), but most contained 3 spores; I did not observe 4 spores in any. The asci were frequently above 8 in number, in one case being as numerous as 18; this character, however, is not important, as there are often less than 8 asci in undoubted examples of *P. corylea*. The two examples showed no other differences, and there is therefore no reason to consider "*P. Candollei*" as more than a mere form of *P. corylea* with frequently 3 (or even, perhaps, sometimes 4) spores in the ascus. It is curious that *Phyllactinia* has not been reported on *Nyssa* since Léveillé's time. The specimen on which Berkeley's record of "*P. Candollei*," from Canada (Poe), in Grevillea, **4**: 158. 1876, was based, agrees in every way with *P. corylea*.

I have not been able to see a specimen of *P. antarctica* Speg., found on *Ribes Magellanicum* in Patagonia, but from the description given have no hesitation in referring it to *P. corylea*. Spegazzini records: "*P. suffulta* (Reb.) Sacc. [*P. corylea*] as occurring on *Anarthrophyllum rigidum* from the same region, and gives a good description of the fungus. Speggazzini's diagnosis of *P. antarctica*, however, applies better to the more usual form of *P. corylea* than does his diagnosis of the form of "*P. suffulta*" mentioned above, and there can be no doubt that both specimens are referable to *P. corylea*.

P. berberidis Palla is a very interesting form. In Palla's valu-

able paper mentioned above, the *Phyllactinia* growing on barberry leaves is described as a new species under this name. The author remarks (264, p. 64) that "die *Phyllactinia* der Berberitzenblätter zwar sehr nahe der *P. suffulta* der Haselnussblätter steht, sich aber von ihr *constant* vor allem durch die an der Spitze stark gebräunten Perithecien-Anhängsel unterscheidet und demnach als eine eigene Art anzusprechen ist." At page 56 (loc. cit.) the same character is more closely described: "An ihrer Spitze sind die vollkommen ausgebildeten Anhängsel bei *P. suffulta* ziemlich stark verschmälert und häufig etwas geschlängelt; die *abgestorbenen Plasmareste sind stets farblos* und reichen sehr oft nicht bis in das Ende der zart-wandigen Spitze hinein, an der nicht selten das Anhängsel collabirt erscheint. Bei *P. berberidis* sind die Anhängsel an der Spitze nur wenig verschmälert; *die hier vorhandenen abgestorbenen Plasmareste sind immer mehr minder stark gebräunt* und gehen bis in das Spitzen-ende hinein; meist erstreckt sich die Färbung auf das ganze obere Drittel, und nicht selten reicht sie bis zur Mitte des Anhängsels herab."

The brown color of the protoplasmic contents of the apex of the appendages is probably best seen in living plants; and becomes partly lost in dried material. In the dried specimens (now in the Kew Herbarium) kindly sent to me by Dr. Palla, the apex of the appendages is yellow-brown, and the appendage has the appearance shown at Fig. 171 (*cf. pl. 5. f. 2* of Dr. Palla's article).

The other minor differences described as existing between the perithecia of *P. berberidis* and *P. corylea* certainly do not hold good when dealing with the numerous forms of the latter—as perhaps might be expected from the author's statement that only examples of *P. corylea* occurring on *Corylus* in Austria were taken into consideration in making the comparison.

With regard to the value that should be attached to the presence of the colored tips of the appendages it seems to me very probable that the color is to be considered as wholly due to the influence of the particular host on the fungus. We know that the barberry contains a yellow coloring matter (berberin), and I am inclined to attribute to the effect of this substance on the fungus not only the colored tips of the appendages, but also the very bright yellow color of the asci and spores. With regard to these

highly colored asci and spores there is every appearance of the condition being a pathological one.

On the whole, it appears best to consider the *Phyllactinia* on *Berberis* as a form slightly affected by certain peculiarities of the host-plant, and not morphologically distinct from *P. corylea*.

Dr. Palla is mistaken in stating that *Phyllactinia* had not previously been reported on *Berberis*. Saccardo has distributed specimens from Italy (Sacc. Myc. Ven. 895, *Phyllactinia guttata*, f. *Berberis vulgaris*); Passerini (272), and many other authors have recorded it from other places in Europe, and Berkeley (35), Farlow (122), Burrill (60), etc., report it from America.

Erysiphella Carestiana was described by Saccardo as being destitute of appendages, and consequently referable to the genus named. Professor Saccardo very kindly sent me the type-specimen for examination. The fungus is *P. corylea;* some of the perithecia have lost their appendages, but some show a few perfect ones, and many have retained a ring of the bulbous bases of the appendages. The fungus was recorded as growing on the damp pileus of *Fomes fomentarius*, but there is now every reason, I think, for believing that it did not originate there. Certainly the perithecia adhere firmly to the pileus of the *Fomes*, but there is as regards the present species, clear evidence for disregarding mere attachment as a proof that the fungus originally grew there. Dr. Palla, when sending me specimens of the *Phyllactinia* on *Berberis*, wrote that the fungus was always hypophyllous, and mentioned that the perithecia which were to be found on the upper surface of the leaves sent, owed their presence there to the pressure of the under sides of other leaves. Without such warning, one would certainly have considered these perithecia as originally growing on the upper surface of the leaf, for they were firmly attached to the substratum, and like the specimens on the pileus of the *Fomes* required some little force to move them with a needle.

This reattachment of the perithecium is brought about by the mucilaginous branches of certain special apical outgrowths. In the case of the *Phyllactinia* on the *Fomes*, Professor Saccardo states (52) that the pileus of the "host"-fungus was moist; this favors the idea that a reattachment by means of the mucilaginous branches had taken place. I am glad to be able to state that

Professor Saccardo now agrees with the view that the position of *Phyllactinia* on the *Fomes* is in all probability an accidental one.

Hitherto the presence of attached perithecia on a leaf has naturally been considered as conclusive proof that the fungus originated there, but for the reasons mentioned above, such proof now becomes invalid. It is therefore very desirable that the reported occurrences of *P. corylea* on *herbs* should be investigated in the field, as it is impossible to prove from the examination of herbarium specimens (unless perithecia can be observed springing from a mycelium) if the fungus originated on the plant in question. An observation of Fuckel's (133, p. 80) perhaps refers to this reattachment of perithecia. This author remarks "dass die Perithecien auf in der Nähe stehende Pflanzen, wie Gräser usw. ueberwucherten. Dasselbe mag wohl auch der Fall sein mit jenen, welche Bagge auf *Pertusaria* fand."

Professor Miyabe has sent me specimens (now in the Kew Herbarium) of a very beautiful form of *P. corylea* from Japan, growing on *Paulownia imperialis*. The form is remarkable for its large size. Many of the perithecia reach a diameter of 350 μ; the appendages are more numerous than usual, being sometimes as many as 25, when they are arranged so closely round the perithecium that their bulbous bases touch one another. In these perithecia the asci and spores show, likewise, a tendency to be larger than usual. Intermixed with these large perithecia, however, are others which, in the smaller size of all their parts, agree perfectly in every respect with ordinary *P. corylea*. Altogether, we cannot consider that the *Phyllactinia* on *Paulownia* is anything but a luxuriant form of *P. corylea*, which it would be inadvisable to separate even as a variety. It is most probable that further search on other Japanese plants would bring to light a complete series of forms of *Phyllactinia* intermediate in size between this large form on *Paulownia* and those of normal size.

Since writing the above, I have noticed that Atkinson (9) has described a form of *Phyllactinia* occurring on certain American oaks (*Quercus Phellos*, *Q. nigra*) as variety *macrospora*. The form, from the description, is evidently comparable to the Japanese plant mentioned above. The perithecia, apparently, are not so large (200–250 μ in diameter), but the very large asci, reaching

to 120 × 50 μ, and spores 35–50 μ long, are similar to those of the Japanese form. Both, I feel convinced, are to be considered as merely large forms of *P. corylea*, quite unable to be separated systematically.

Erysiphe detonsa Fries is, in all probability, the present species, as Léveillé has contended (214, p. 145). In the Friesian Herbarium there is a specimen named "*E. detonsa*" in Fries' handwriting, and this is certainly *P. corylea*. This specimen occurs on the wood of *Fraxinus*, however, and is, therefore, not the type which is described in Syst. Myc. as growing on *Tanacetum vulgare*. I have seen the specimens on *Tanacetum vulgare* (in Montagne's Herbarium at the Paris Museum), which Léveillé has stated came from the same source as those on which Fries founded his species, and find that these also belong, as Léveillé has said, to *P. corylea*. It is true Fries says of his plant "peridiolo solitario"; with the exception of this character, however, the description applies well to imperfect examples of *P. corylea*, and it is to be noted that Fries says "Peridia . . . facie *E. guttatae*." The fungus identified by Kickx as Fries' *E. detonsa* is the *Sphaerotheca* called *S. humuli*, var. *fuliginea* (see Sacc. Syll. Fung. **1**: 4; also Oudem. Rév. Champ. Pays-Bas, **2**: 84–85.

In the description of *P. corylea* above it is mentioned that the perithecia possess a mass of special apical outgrowths. The nature of these outgrowths has been until quite recently completely misunderstood. Each outgrowth, which springs from the external face of a cell of the outer wall of the perithecium, consists of a stalk-cell (Fig. 173, *a*), bearing a terminal mass of densely-clustered, short, swollen, more or less tubular branches (Fig. 173, *b*). Sometimes the stalk cells branches irregularly before giving rise to the branches. At a certain stage of development, the branches of each outgrowth become mucilaginous, and their separate walls more or less indistinguishable (Fig. 174, *a*). In this mucilaginous condition, the outgrowths which arise in a dense mass from the apical cells, cause the firm attachment of the perithecium to the substratum. During the process of this mucilaginous degeneration, the walls of the hyphal branches become more or less dissolved and are invisible without staining, while the protoplasmic contents of each branch remain distinct, especially toward the apex (Fig. 175); at

this stage each outgrowth has much the appearance of a stem-cell bearing a number of stalked spores. An interesting point in connection with these apical outgrowths is the power they possess, after the perithecium on which they occur has been detached from its original substratum, of again becoming mucilaginous and so causing the reattachment of the perithecium to foreign objects. As mentioned above, the occurrence of *P. corylea* on the pileus of *Fomes fomentarius* is probably to be accounted for in this way, and the same explanation is perhaps to be given to many of the recorded cases of the occurrence of *P. corylea* on herbaceous plants.

The explanations given of the apical outgrowths by previous authors have been very different. Nägeli (256) described the structures as a parasitic fungus under the name of *Schinzia penicillata* (afterwards changed to *Naegelia penicillata* by Rabenhorst) Bonorden (49) stated that they were part of the fungus, but that they sprang from the inner wall of the perithecium and surrounded the asci. Tulasne (369 and 370) fully described the outgrowths, and placed these structures on the organic apex of the perithecium (see 370, *tab. 1*). Vüillemin (379) repeated Bonorden's error of supposing that the structures originated internally.

Quite recently, however, Neger (258) has published a preliminary note on *Phyllactinia*, in which the author attributes to the outgrowths the function of anchoring the perithecium to the leaf; the conclusion to which I had already arrived from the study of a large amount of herbarium materials from all parts of the world (see Journ. of Botany (314), where a more complete account of the views of previous authors on the nature of the outgrowths is given). In this article I stated that the penicillate cells spring from the *base* of the perithecium. In a paper by Dr. Neger (Bericht. Deutsch. Botan. Gesell. **17**: 235–242. *pl. 23.* 1900) appearing shortly afterwards, the author, from the study of living specimens, described and figured these outgrowths as springing from the apex of the perithecium. This led me to reëxamine perithecia, with the result that I found Dr. Neger's statement to be perfectly correct. I can only suppose that in the section from which the Fig. 6 (Journ. of Bot.) was drawn, the asci were really loose, and dragged round in the process of cutting. The firm attachment of the perithecium by the outgrowths also led me at that time to

think that the latter sprang from the organic base of the perithecium, whereas as Dr. Neger (*l. c.*) has shown, the perithecium, when so fixed, is really turned upside down. Neger has briefly mentioned that in a *Phyllactinia* from the Argentine examined by him the outgrowths were characterized by a much-branched stalk-cell, and on this account the author regards the fungus as a new species of *Phyllactinia*, and proposes the name *P. clavariaeformis*. As a full description and figures of the plant are promised, the question of its specific distinctness must be left open until these appear, although as I have already pointed out (314, p. 453. *f. 3*) the validity of the character relied upon seems doubtful.

Richon (298) describes a fungus which attacks the leaves and stems of *Poa nemoralis* and *Festuca sylvatica*, and gives the name "*Erysiphe graminis?* DC." to the plant, but remarks: "Les périthèces soul ornés de 6 ou 8 appendices, simples et renflés à la base. Il constitue probablement une variété de *Phyllactinia suffulta* non signalée par les auteurs et différente de *l'Erysiphe graminis* de Saccardo." It will be well to ascertain if the *Phyllactinia* was actually growing on the plants mentioned, before adding grasses to the list of the host-plants of the species.

P. corylea is sometimes mentioned among the diseases attacking cultivated nut trees, but I have found no statement that it has ever caused any serious injury. Pammel (268, p. 103) mentions that *Phyllactinia* "occurred destructively on *Fraxinus*," at Ames, Iowa.

DOUBTFUL OR EXCLUDED SPECIES

Erysiphe radiosum Fr. Obs. Myc. **1**: 207. 1815 = *Actinonema rosae* (Lib.) Fr.

E. album Fr. *l. c.* No specimen seen.

Alphitomorpha rosarum Wallr. Ann. Wett. Ges. **4**: 238. 1819. No specimen seen. Wallroth gave the following description: "A subiculo subtilissimo fere obsoleto, sporangiis parvis sparsis sphaericis, capillitio obsoleto. Hypophylla in *Rosa cinnamomea*, rarior. Species ob minutiem sporangiorum facile praetervidenda, nec quoque subiculo detegenda, quod cum tomento folii obductum est. Dubiam igitur modo indico." In Fl. Crypt. Germ. **2**: 755. 1833. Wallroth placed it as a variety under "*A. penicillata*."

A. epigaea Wallr. Berl. Ges. Nat. Freund. Verhandl. **1**: 44. 1819; and Ann. Wett. Ges. **4**: 246. 1819. From the description given there is no doubt that this fungus is to be placed outside the Erysiphaceae, as Dietrich (107, p. 343) has already remarked. Karsten (194) considers it the "sclerotium-stage" of *Lanosa nivalis* Fr.

A. epixylon Schlect. Berl. Ges. Nat. Freund. Verh. **1**: 50. 1819. No specimen seen.

Erysibe acariforme (Sow.) Gray, Nat. Arr. Brit. Pl. **1**: 590. 1821 = *Hypoxylon coccineum* Bull.

E. Sowerbii Gray, *l. c.* = *Coprinus radiens* (Desm.) Fr.

Erysiphe Tordylii Chev. Fl. Par. **1**: 380. 1826. On *Tordylium maximum*. No specimen seen; very probably *E. polygoni*.

Erysibe Wallr. Fl. Crypt. Germ. **2**: 198–218. 1833. All the species of this genus belong to the Uredineae (*Uredo, Ustilago, Puccinia, Tilletia*, etc.).

Erysiphe lathyri Mér. Rev. Fl. Par. 459. 1843. On *Lathyrus latifolius*. No specimen seen.

E. saxifragae sibericae Mér. *l. c.* On *Saxifraga Siberica*. No specimens seen.

E. tiliae Mér. *l. c.* On the lime. No specimens seen.

Phyllactinia Schweinitzii Lév. Ann. sci. nat. III. **15**: 150. *pl. 7. f. 13*. 1851; Sacc. Syll. Fung. **1**: 6. 1882. Léveillé made two sections of his genus *Phyllactinia*—one characterized by the bulbous appendages, the other described as possessing "Appendiculae nigrae vesicula basilari destitutae." The latter contained only *P. Schweinitzii*, described as follows: "Hypophylla. Mycelio arachnoideo evanido. Conceptaculis magnis, sparsis, hemisphaericis, demum depressis. Sporangiis . . . sporis . . . appendiculis nigris. Hab. Meudon, ad folia *Quercus sessiliflorae*. Obs. J'aurais dû passer sous silence cette espèce, comme je l'ai fait de beaucoup d'autres dout je n'ai pas vu la fructification, mais je ne le pouvais pas; ses appendicules solides, noires et dépourvues de vésicules à la base lui impriment un caractère particulier qui empêche de la confondre avec aucune autre espèce connue jusqu'à ce jour." Nothing further has been known about this species since Léveillé's time, and I have not been able to find any example among the specimens of Erysiphaceae sent by Léveillé to

various authors. From the description of the appendages the plant evidently does not belong to the genus *Phyllactinia*—very probably not to the Erysiphaceae at all. The diagnosis given, however, is much too incomplete to admit of an identification of the plant, and if, as seems to be the case, no specimens exist, the name should be dropped.

Erysiphe nerviseqüia Westend. Bull. Acad. Roy. Belg. **21**: 231. 1854. Westendorp's description is as follows: "Subicule nul, peridium punctiforme, très-petit (1/10e de mille de diamètre), globuleux, d'abord orangé, puis brun et enfin noir, luisant, attaché par quelques fibrilles rares au support et contenant un seul péridiole globuleux—Cette espèce, qui forme des lignes pointillées sur les nervures de la feuille . . . se développe sur les deux faces des feuilles du *Stachys palustris*." Namur, Belgium. I have seen specimens from Westendorp's herbarium (as well as others sent to me by Professor Pâque as *Erysiphe communis* var. *labiatarum*), and find that the fungus does not belong to the Erysiphaceae. The perithecia are from 70–80 μ in diameter, rather irregular in shape, but more or less globose-depressed, with a fragile, membranous wall composed of small rather distinct dark brown cells, 4–5 μ wide. The perithecia occur scattered sparingly on both sides of the leaf, and also occasionally in denser patches on the stem. The so-called "péridiole" is in reality a multicellular structure, and is perhaps the separating inner wall of the perithecium. Within this oval or spherical structure, some bodies which resembled very young asci were observed, but none of the material examined was ripe enough to allow of the generic identification of the fungus. It seems probably, however, that the plant will prove to belong to the Eurotieae.

Erysibe andreaeaceaerum and *E. chroolepidis* Reinsch. Contrib. Algol. et Fungol. 96 (1874–5) belong to the Algae. Hariot (Journ. de Bot. **3**: 405. 1889) states that the latter species is *Trentepohlia Monilia* de Wildem. (see however, Magnus, 230).

? *Phyllactinia fungicola* (Schulz.) Sacc. Syll. Fung. **1**: 6. 1882. *Erysiphe fungicola* Schulz. Oest. Bot. Zeit. **26**: 58. 1876.

Saccardo gives the following diagnosis: "Peritheciis brunneofuscis, sphaericis, 300 μ. diam., subiculo mucedineo stellatim effuso insidentibus; conidiis in hyphis acrogenis brunneis; appen-

dicibus radiatis, basi inflatis; ascis vesicularibus, copiosis, 1–2-sporis; sporidiis ovato-cylindraceis, 4×1.5. Hab. In superficie *Boleti duriusculi* Slavonia.—Videtur *Phyllactiniae* species, sed ob habitationem insuetam dubia. Turning to Schulzer, we find this description: "*Erysiphe fungicola* Schlzr. fand ich gegen Ende Oktober, im Nustarer Walde bei Vinkovce, zerstreut auf der Oberfläche meines *Boletus duriusculus* im erkrankten Zustande. Die Pyrenien sind schwarzbraun, kuglich, dann am Scheitel einsinkend, 0.3 mm. breit. . . . Sie sitzen, jede für sich, auf einen aus strahlenförmigen kürzeren und längeren Hyphen bestehenden Mycelium. Die längeren, unter sich von fast gleicher Grösse, verdicken sich an der Spitze und es entsteht eine einfache oder einmal septirte, braune, später abfallende Conidie oder Chlamydospore, während der Faden selbst ungefärbt ist. Weiter oben gehen vom Pyrenium in geringer Zahl steif-radienförmige an der Basis blasig erweiterte Fulcri mit einfacher Spitze ab. Ihre Länge beträgt beiläufig den doppelten Pyrenium-Durchmesser."

The asci and spores are described as in Saccardo's translation, except that the size of the latter is stated to be 40×15 μ. Although the characters of the occasional septation and the brown color of the spores do not fit *Phyllactinia corylea*, Schultzer's description in other respects seems to point to this species. *P. corylea* has been recorded lately as occurring on the pileus of *Fomes fomentarius*, but in this case the occurrence of the *Phyllactinia* was merely accidental. In the case of "*E. fungicola*," the presence of mycelium and conidia indicate (if these really were in connection with the perithecia) that the fungus originated on the *Boletus*.

Erysiphe? scandens Ernst (Monatsch. Ver. Beförd. Gart. preuss. Staat. 1878: 400)=*Pellicularia Koleroga* Cooke (see Grevillea, 9: 10. 1880).

Microsphaera Bresadolae (Quél.) Bres. in litt., Sacc. Syll. Fung. 9: 368. 1891; *Podosphaera Bresadolae* Quélet in Bresad. Fung. Trid. 25. *pl. 30. f. 2.* 1881. Quélet's description is as follows: "Perithecia globosa, membranacea, superficialia, sparsa, minutissima, late reticulata, e luteolo rufescentia, demum nigricantia, 90 mmm. diam.; appendiculae hyalinae, perithecio duplo majores, apicibus turgidis dichotomo ramosis praeditae; asci subglobosi, 8-spori, mox evanidi, 50 mmm., sporae ovatae, luteolae, echinu-

latae, 15–20 × 12 mmm. Autumno. In pileo *Arrheniae auriscalpium* Fr. in sylvis umbrosis mixtis. Val di Sole. *Podosphaera clandestinae* Lév. affinis." Saccardo gives the same description and adds "ascis . . . in quoque perithecio pluribus. . . . Etsi matrix tam absona, species generis optima videtur." In Quélet's figure a perithecium is shown with appendages which certainly recall those of the genus *Microsphaera*. On the other hand, the echinulate yellowish spores, if these are correctly described, would be anomalous characters. Overlooking these spore characters, the suggestion may perhaps be made that perithecia of some species of *Microsphaera, e. g., M. alni*, may have accidentally become attached to the pileus of the *Arrhenia*. Abbe Bresadola informs me that unfortunately the type specimen is lost.

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EXPLANATION OF PLATES

(Unless otherwise stated, all figures are magnified 400 times)

PLATE 1

Figs. 1–14. *Microsphaera alni*, apex of the appendage in different forms of the species. 1, from a specimen on *Syringa* (American); 2, on *Gleditschia triacanthos* (from the type specimen of "*M. Ravenelii*"); 3, on *Viburnum Opulus* ("*M. penicillata*," from specimen from Léveillé's herb.); 4, 5, 6, on *Cornus alternifolia* (from the type specimen of "*M. pulchra*"); 7, on *Castanea* (American); 8, on *Betula alba* ("*M. Friesii*," from specimen from Léveillé's herb.); 9, 10, on "*erineum*"-galls on the leaf of *Fagus ferruginea* ("*M. erineophila*"); 11, on *Nemopanthes fascicularis* ("*M. Nemopanthis*"); 12, on *Viburnum Lantana* ("*M. Hedwigii*," from specimen from Léveillé's herb.); 13, 14, on *Cephalanthus occidentalis* (from the type specimen of "*M. semitosta*").

Figs. 15–17. *M. alni* var. *calocladophora*, apex of three appendages.

Fig. 18. *M. alni* var. *extensa*, apex of an appendage.

Figs. 19, 20. *M. alni* var. *lonicerae* (from specimen named "*M. Dubyi*" from Léveillé's herb.).

Figs. 21, 22. *M. alni* var. *lonicerae* (from specimen named "*M. Ehrenbergii*").

Figs. 23–25. *M. alni* var. *divaricata*, apex of three appendages.

PLATE 2

Fig. 26. *M. alni* var. *divaricata*, apex of an appendage.

Figs. 27–30. *M. alni* var. *ludens*, apex of four appendages.

Figs. 31–33. *M. diffusa*, apex of three appendages. 31, from specimen on *Desmodium*, Wisconsin; 32, from type specimen of *M. diffusa*; 33, from specimen on *Symphoricarpos racemosus* ("*M. symphoricarpi*").

Figs. 34–37. *M. grossulariae*; 34, 35, apex of two appendages from European specimens on *Ribes grossularia*; 37, part of the outer wall of the perithecium, from same specimens, 36, apex of an appendage (immature) from an American specimen on *Sambucus* ("*M. Van-Bruntiana*").

Figs. 38, 39. *M. Russellii*, apex of two appendages.

Figs. 40, 41. *M. berberidis*, apex of two appendages.

Fig. 42. *M. guarinonii*, half of the apex of an appendage.

PLATE 3

Fig. 43. *M. grossulariae*, mature apex of an appendage, from an American specimen on *Sambucus* ("*M. Van-Bruntiana*").

Fig. 44. *M. guarinonii*, apex of a nearly mature appendage.

Figs. 45, 46. *M. umbilici*, apex of an appendage, ascus and ascospore.

Figs. 47–51. *M. astragali*; 47–50, apex of four appendages, 51, part of perithecium, showing inner (*a*) and outer (*b*) walls.

Figs. 52–55. *M. Bäumleri*, apex of two appendages, ascus and ascospores.

Figs. 56–58. *M. ferruginea*, apex of two appendages, ascus and ascospore.

Figs. 59, 60. *M. Mougeotii*, apex of an appendage, and ascus.

Fig. 61. *Uncinula australis*, asci and ascospores.

Figs. 62, 63. "*U. Columbiana*" appendages, ascus and ascospores (from type specimen).

PLATE 4

Figs. 64–68. *U. Sengoku'i;* 64, perithecium with appendages, × 150; 65, 66, three appendages; 67, asci and ascospores; 68, part of outer wall of perithecium.

Figs. 69–72. *U. fraxini;* 69, perithecium with appendages × 150; 70, single appendages, and the apex of three others; 71, asci and ascospores; 72, part of wall of perithecium.

Figs. 73–78. *U. salicis* var. *Miyabei*, 73, perithecium with appendages, × 150; 74, 75, three appendages; 76, 77, branched apex of two appendages; 78, asci and ascospores.

PLATE 5

Figs. 79, 80. *U. prunastri*, appendages, asci and ascopores.

Figs. 81, 82. *U. Clintonii*, appendages, asci and ascopores.

Figs. 83, 84. *U. flexuosa*, two appendages and germinating conidium.

Fig. 85. *U. salicis*, helicoid apex of four appendages, from specimen on *Populus balsamifera* ("*U. heliciformis*").

Fig. 86. *U. necator*, base of an appendage, showing abnormal enlargement, from specimen on *Actinidia* from Japan.

Fig. 87. *U. aceris*, apex of five appendages (*a*, slightly flattened).

Fig. 88. *U. Delavayi*, asci and ascospores.

Fig. 89. *U. polychaeta*, asci and ascopores.

Figs. 90, 92. *Oidium-like* fungus occurring with the mycelium of *U. aceris*, var. *Tulasnei;* 90, conidiophores; 92, conidia.

Fig. 91. *Oidium* occurring on the same leaf with the above.

Fig. 93. *U. clandestina*, appendage and asci.

Figs. 94, 95. *U. Australiana*, two appendages, asci and ascopores.

Figs. 96, 97. *Podosphaera oxyacanthae*, appendage from European specimen on *Crataegus Oxyacantha; a, b, c*, successive stages in the development of the young appendage.

Fig. 98. *P. biuncinata*, apex of three appendages.

PLATE 6

Figs. 99–108. *P. oxyacanthae*, apex of appendages and asci; 99, 100, from specimens on *Pyrus Aucuparia* ("*P. aucupariae*"); 101, 102, from American specimens; 103, 104, from specimens on *Pyrus Germanica* ("*P. Clandestina*" ex herb. Léveillé); 105, from specimen on *Spiraea salicifolia* ("*Microsphaera fulvofulcra*"); 106, 107, 108, three asci, showing variation in size.

Figs. 109–114. *P. oxyacanthae* var. *tridactyla*, apex of appendages, ascus and ascospores.

Fig. 115. *P. oxyacanthae*, conidial (*Oidium*) stage showing conidiophore and conidia.

Figs. 116, 117. *Sphaerotheca humuli* (on *Spiraea ulmaria*), conidial (*Oidium*) stage (116, portion of a leaf, showing mycelium and five conidiophores, × 150; 117, single conidiophore and conidia).

Fig. 118. *Podosphaera Schlechtendalii*, ascus and ascospores.

PLATE 7

Figs. 119–122. *Podosphaera leucotricha;* 119, 120, two perithecia, with apical and basal appendages, × 95; 121, ascus and ascospores; 122, branched apex of two appendages.

Fig. 123. *P. Schlechtendalii*, apex of two appendages.

Figs. 124–126. *Sphaerotheca phytoptophila*: 124, perithecium artificially burst open, forcing out the ascus and the inner wall, × 255; 125, portion of the inner wall; 126, ascus and ascospores.

Figs. 127–129. *Erysiphe galeopsidis* on *Stachys sylvatica*; 127, conidiophores and conidia; 128, 129, hyphae, showing lobed haustoria (128 × 980).

Fig. 130. Lobed haustoria of *Erysiphe* on *Eupatorium ageratoides*, × 670.

Figs. 131. Haustoria of *Erysiphe cichoracearum* on *Sonchus arvensis*, × 670.

Figs. 132–139. *E. polygoni*; 132, asci (a typical form); 133, from specimen on *Lupinus*; 134, from specimen on *Cnicus lanceolatus*; 135–139, ascospores; 135, from specimen on *Polygonum*; 136, on *Circaea Lutetiana*; 137, on *Lupinus*; 138, on *Cnicus lanceolatus*; 139, on *Parnassia Caroliniana*.

Fig. 140. *E. cichoracearum* (on *Arctium*), conidiophore and conidia; *a*, *b*, *c*, *d*, successive stages in the development of the young conidiophore.

PLATE 8

Figs. 141, 142. *Erysiphe trina*; 141, two perithecia; 142, ascus and ascospores.

Fig. 143. Asci and ascospores of "*E. vernalis*."

Fig. 144. *E. aggregata*, two asci.

Figs. 145–150, 152–154. *E. taurica*; 145–147, 149, three appendages and ascus, from the type specimens of "*Microsphaera Bornmuelleriana*"; 148, 150, two appendages and ascus from the type specimen of "*E. lanata*"; 152, 153, ascus and ascospores from specimens from Léveillé's herbarium; 154, ascus of "*E. papilionacearum*."

Fig. 151. *E. cichoracearum*, asci and ascospores.

Fig. 155. *E. polygoni* on *Polygonum aviculare*; section showing a hypha of the mycelium forming a haustorium in an epidermal cell, × 670.

Fig. 156. *E. graminis*, on *Hordeum*, conidial stage (*Oidium monilioides*).

PLATE 9

Fig. 157. *E. polygoni* var. *sepulta*; asci and ascospores.

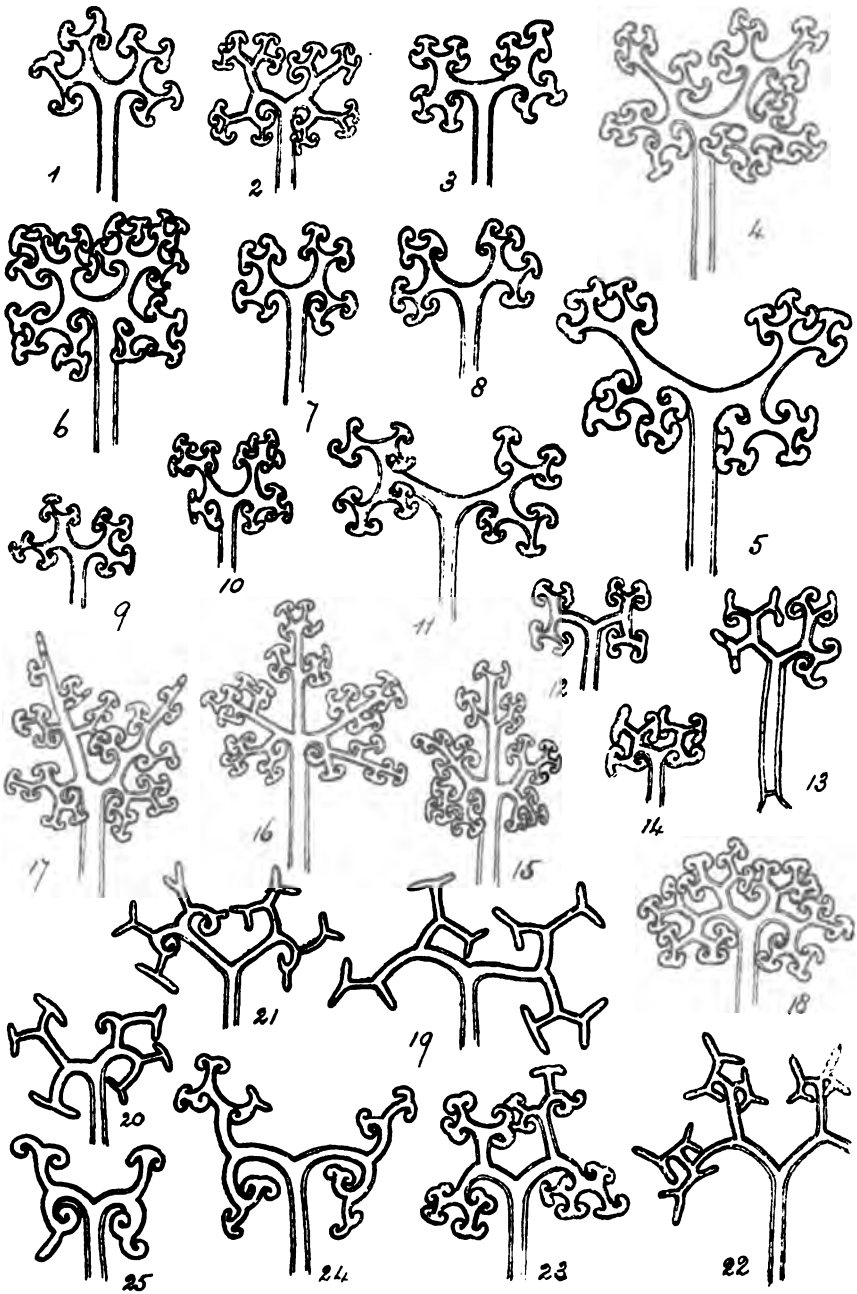
Fig. 158. *E. polygoni*, on *Quercus glauca*; ascus and ascospores.

Figs. 159, 160. *E. graminis*; 159, two asci, with 8 spores formed in each, from the specimen in Rab. Fung. Eur. 671; 160, two asci (from European examples).

Fig. 161. "*Oidium Balsamii*," conidia (from specimen from Montagne's herbarium).

Fig. 162. "*O. Balsamii*" on turnips (W. G. Smith in herb. Cooke).

Figs. 163–175. *Phyllactinia corylea*; section of leaf of *Berberis vulgaris*, showing a special hypha ("Ernährungshyphe") of the mycelium passing through a stoma into the intercellular spaces, and sending a hausterium into a cell of the spongy parenchyma (the lower half of the hypha is seen passing behind some cells in an intercellular space); 164, ascus from Japanese specimen on *Morus alba*; 165, ascus and ascospores from Japanese specimen on *Paulownia imperialis*; 166, ascus with three spores (from specimen of "*P. Candollei*" from Léveillé's herb.); 167–169, ascus and ascospores; 170–172, appendages; 172, immature stages, × 255; 171, from specimen of "*P. berberidis*"; 173, 174, two outgrowths from the apical cells of the perithecium (173, *a*, stalk cell, *b*, head of hyphal branches; 174, *a* branches beginning to coalesce through mucilaginous degeneration); 175, apex of one of the branches of an outgrowth, at the stage when the wall is partly dissolved and invisible without staining, protoplasmic contents evident and resembling a stalked spore, × 670.



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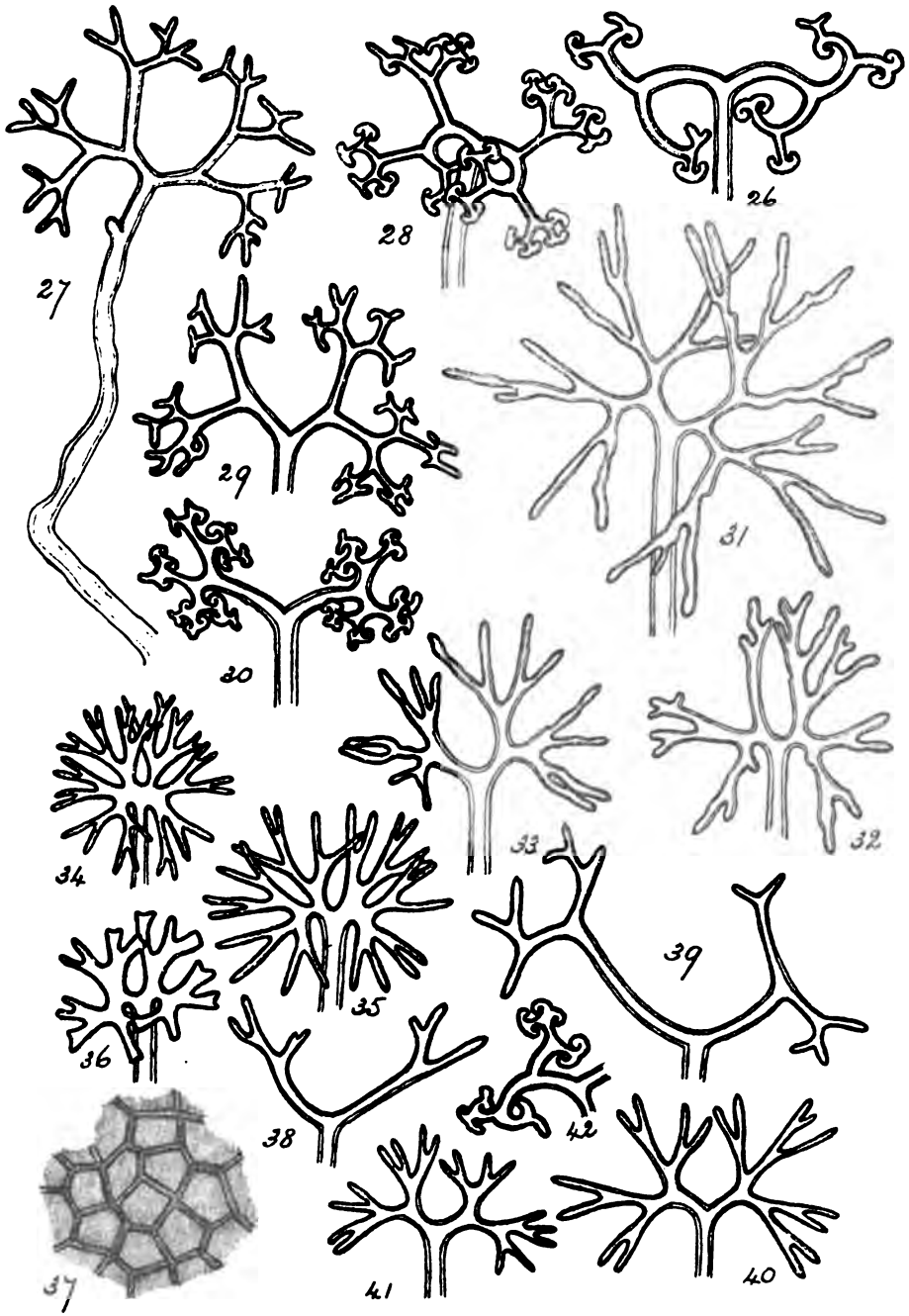

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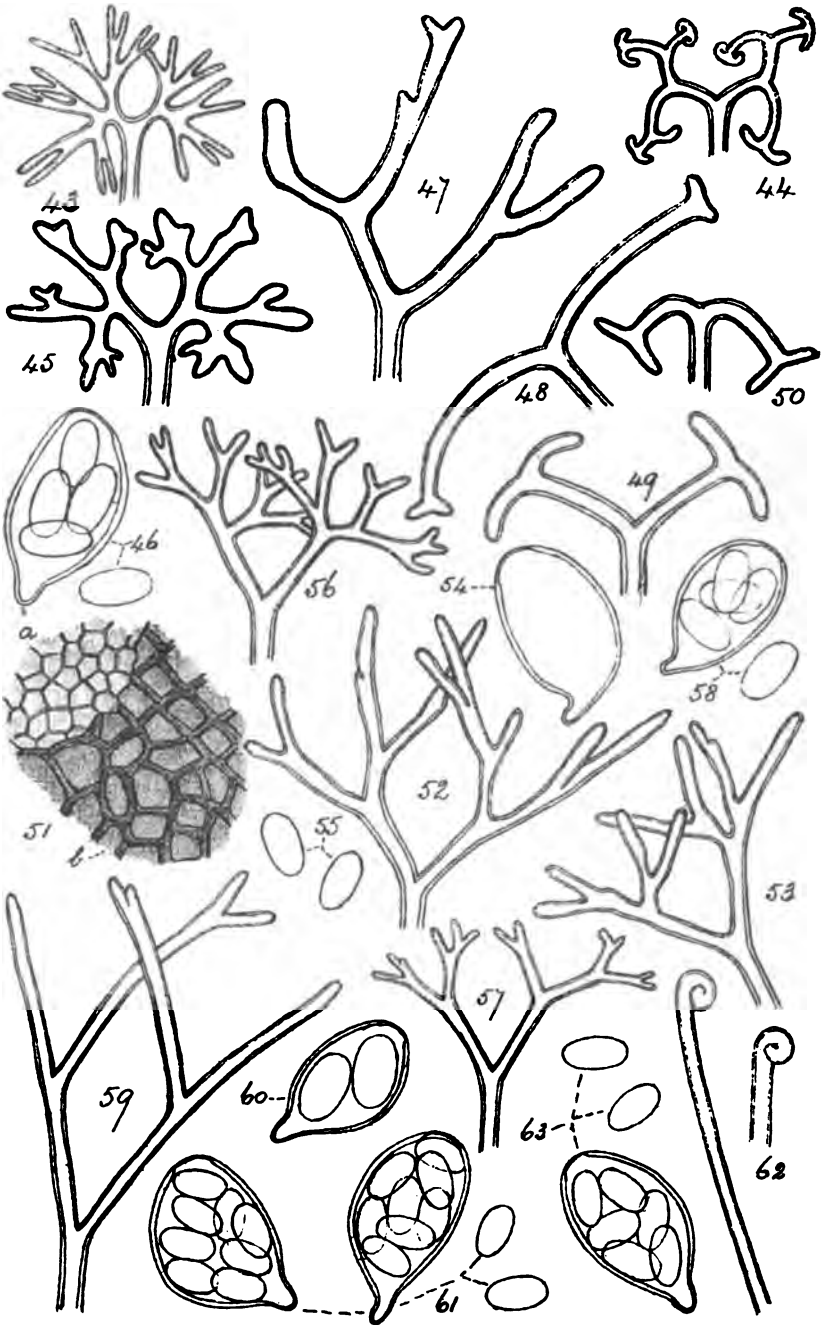

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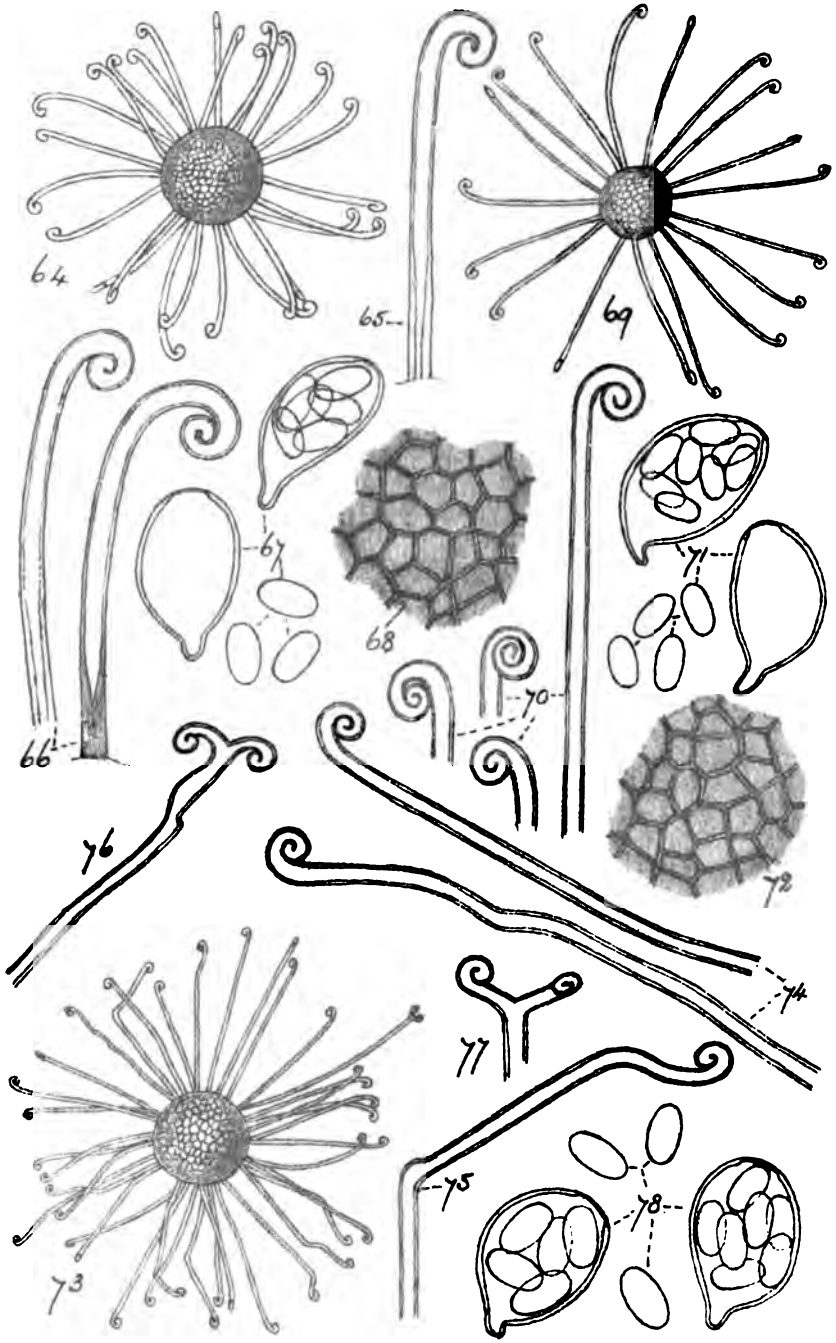

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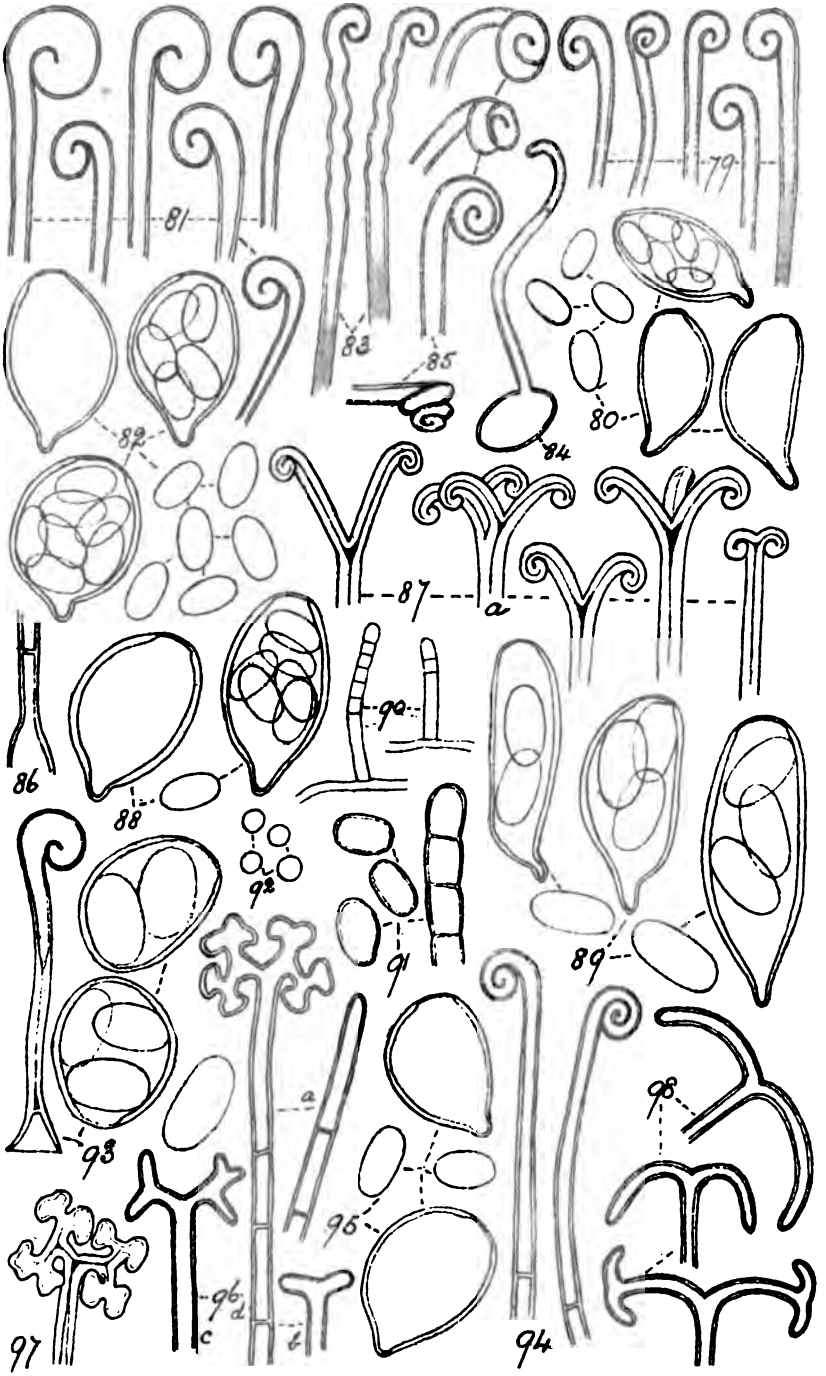

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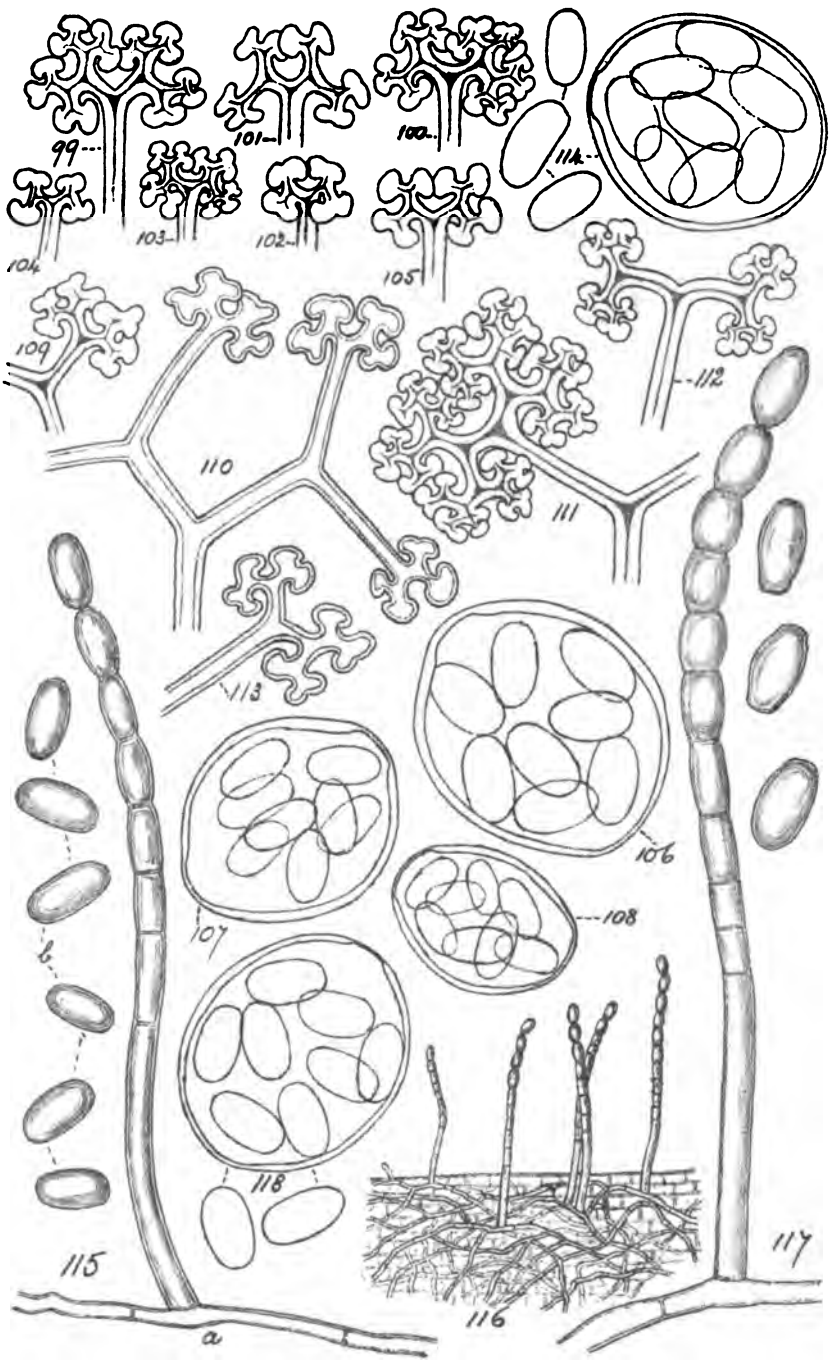

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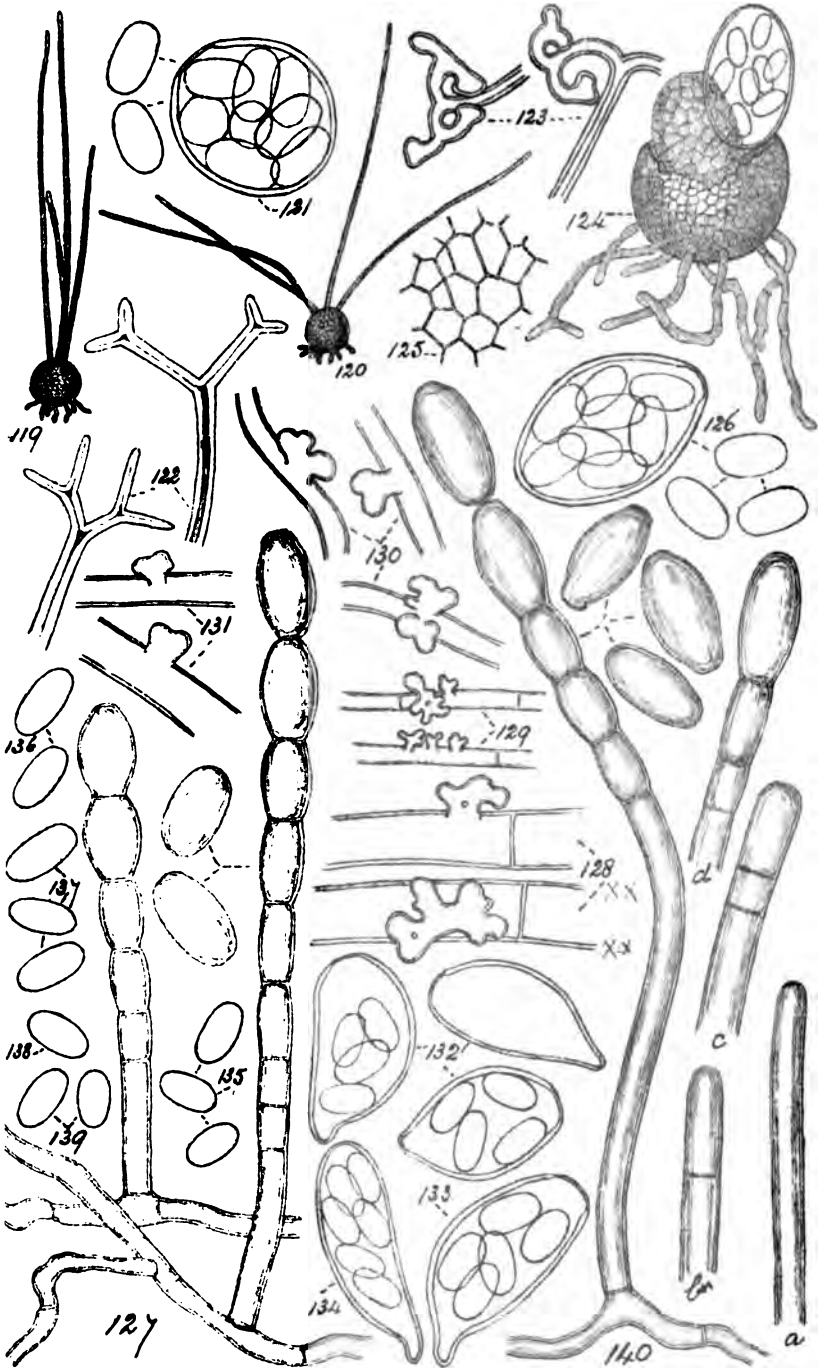

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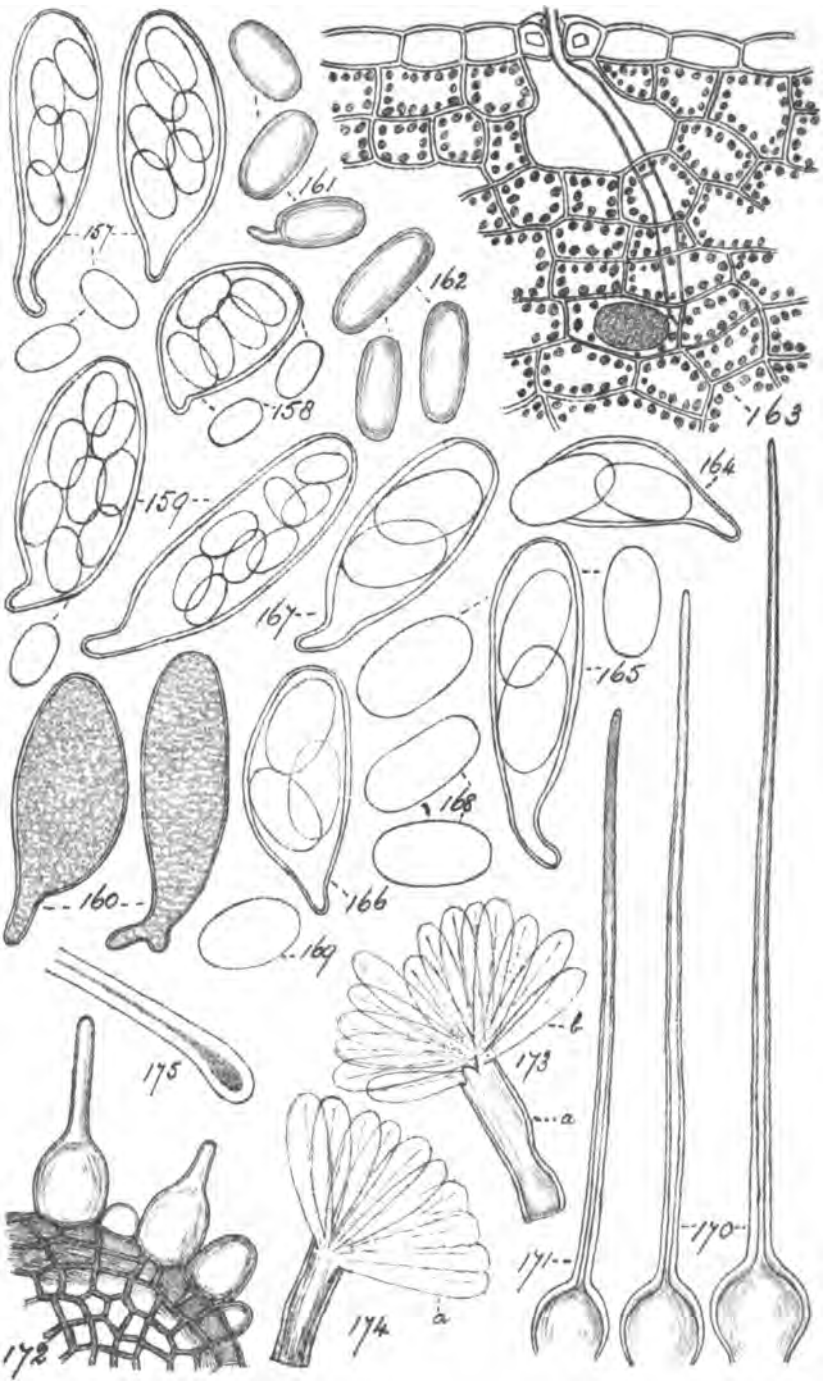

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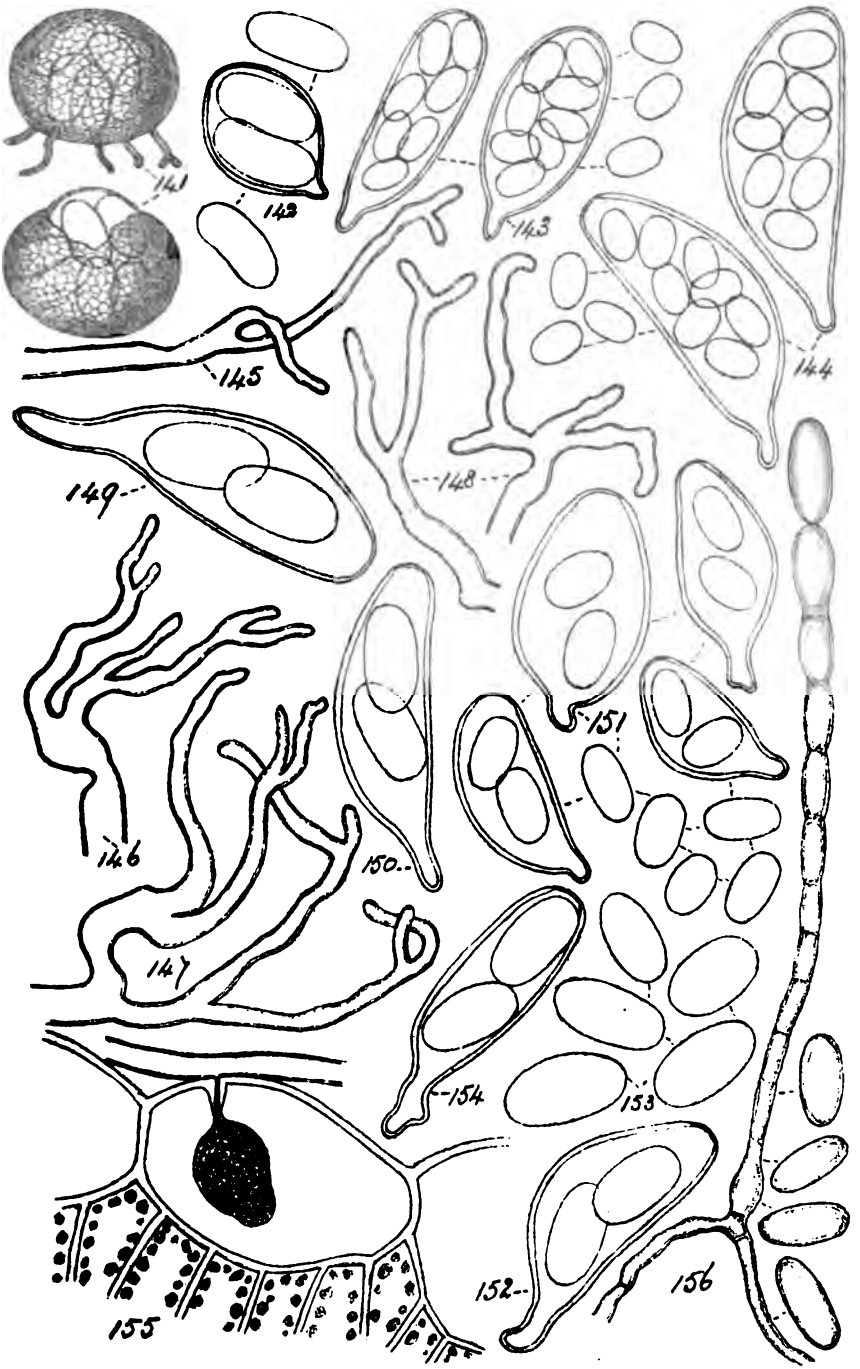

E. S. SALMON, DELT.

HOST–INDEX

Records for plants prefixed by * (before the generic or specific name) have not been personally verified; the authority for these will be found indicated in the list of host-plants given under the species in question. *E.* = *Erysiphe*; *M.* = *Microsphaera*; *P. corylea* = *Phyllactinia*; *P.* = *Podosphaera*; *S.* = *Sphaerotheca*; *U.* = *Uncinula*.

Acanthophyllum glandulosm.....E. taurica.
Acer campestre .....U. aceris.
* " " .....P. corylea.
A. dasycarpum..... U. circinata.
A. monspessulanum.....U. aceris and var. Tulasnei.
*A. Pennsylvanicum.....U. circinata.
A. pictum.....U. aceris.
A. platanoides.....U. aceris and var. Tulasnei.
* " .....P. corylea.
A. Pseudo-platanus.....U. aceris and P. corylea.
* " .....U. aceris var. Tulasnei.
A. rubrum .....U. circinata.
* " .....U. aceris.
A. saccharinum.....U. circinata.
* " .....P. corylea.
A. spicatum..... ..U. circinata and U. aceris.
A. Tataricum.....U. aceris.
Achillea Millefolium, Ptarmica.....E. cichoracearum.
*A. Ptarmica.....E. polygoni.
* " .....E. taurica.
Aconitum *Anthora, Fischeri, Napellus, *paniculatum.....E. polygoni.
Actaea spicata..... "
Actinidia arguta.....U. necator and P. corylea.
A. Kolomikta, polygama.....U. necator.
Actinomeris squarrosa.....E. cichoracearum.
Adenocaulon bicolor .....S. humuli var. fuliginea.
Adenostyles albida..... " "
A. *alpina, viridis.....E. cichoracearum.
*Adonis vernalis.....E. polygoni.
*Aegopodium Podagraria..... "
Aesculus *arguta, *flava, glabra, Hippocastanum, Pavia.....U. flexuosa.
Aethusa Cynapium..... .....E. polygoni.
Agrimonia Eupatoria.....S. humuli.
Agropyron *caninum, glaucum, repens, scabrum, *tenerum..E. graminis.
Agrostis *alba, *exarata..... ..... "
Ailanthus sp .....U. Delavayi.
Ajuga ciliata.... .....S. humuli var. fuliginea.
*A. reptans.....E. polygoni.

Albizzia oplhantha..... "
Alchemilla arvensis, vulgaris.....S. humuli.
Alhagi *camelorum, maurorum.....E. taurica.
Alnus glutinosa.....M. alni and P. corylea.
" × incana.....P. corylea.
A. incana.....P. corylea, E. aggregata, E. polygoni (vernalis) M. alni and U. salicis var. Miyabei.
A. incana var. virescens.....M. alni and P. corylea.
A. maritima..... " " and U. salicis var. Miyabei.
A. rubra.....M. alni and P. corylea.
A. serrulata..... " " and E. aggregata.
A. viridis.....M. alni and E. aggregata.
*Alopecurus agrestis.....E. graminis.
Althaea ficifolia, Kurdica.....E. taurica.
Alyssum calycinum, *campestre.....E. polygoni.
Ambrosia artemisiæfolia, psilostachya, trifida and var. integrifolia.....E. cichoracearum.
*Amelanchier alnifolia.....E. polygoni.
A. Canadensis.....P. oxyacanthae and P. corylea.
*A. maculatum.....E. polygoni.
*Ampelopsis cuspidata.....U. necator.
Amphicarpaea Edgeworthii var. Japonica, monoica.....E. polygoni.
Amsinckia spectabilis.....E. cichoracearum.
Anarthrophyllum rigidum.....P. corylea.
*Anchusa Italica.....E. cichoracearum.
A. officinalis.....E. polygoni.
* " .....E. cichoracearum.
Andromeda sp.....M. alni var. vaccinii.
Anemone dichotoma, *ranunculoides, *thalictroides, Virginiana.....E. polygoni.
Angelica sylvestris.....P. corylea and E. polygoni.
Anthriscus Cerefolium, sylvestris.....E. polygoni.
Antirrhinum Orontium.....E. cichoracearum.
* " " .....E. polygoni.
Apera Spica-venti.....E. graminis.
Aphananthe aspera.....U. polycheta and U. Clintonii.
Apios tuberosa.....M. diffusa and M. alni.
Aplopappus sp.....E. cichoracearum.
*Apocynum sp..... "
Aquilegia Canadensis, vulgaris.....E. polygoni.

*Arabis alpina.....S. "Castagnei."
*A. Turrita .....E. polygoni.
Archangelica officinalis..... "
Arctium majus.....E. cichoracearum and S. humili var. fuliginea.
A. minus.....E. taurica and E. cichoracearum.
A. nemorosum.....E. cichoracearum.
Arenaria decipiens, *juniperina.....E. polygoni.
Aristotelia racemosa..... " (E. densa).
Arnica cordifolia, montana.....S. humuli var. fuliginea.
*Arrhenatherum avenaceum.....E. graminis.
Artemisia Absinthium, *biennis, campestris, *discolor, dracunculoides.....E. cichoracearum.
A. Dracunculus.....E. taurica.
A. glauca, Japonica, Ludoviciana and var. gnaphalodes, vulgaris .....E. cichoracearum.
A. vulgaris.....P. corylea.
* " .....U. salicis.
*Asclepias Syriaca.....P. corylea.
A. variegata.....E. cichoracearum.
Asperugo procumbens..... "
*Asperula odorata..... "
* " " .....E. polygoni.
*Aster adscendens .....E. cichoracearum.
*A. Bellidiastrum.....S. "Castagnei."
A. canescens, communis, commutatus.....E. cichoracearum.
*A. commutatus.....E. polygoni.
A. *conspicuus, cordifolius, *corymbosus, *diffusus, Drummondii, ericoides and var. *villosus, foliaceus, var. Eatoni, Fremonti, *grandiflorus, *junceus, laevis and var. laevigatus, longifolius, *macrophyllus, *multiflorus, *oblongifolius, paniculatus, prenanthoides, puniceus, sagittifolius, *salicifolius, *Shortii, Tradescanti, *umbellatus, *vimineus var. foliolosus.....E. cichoracearum.
Astragalus sp..... .....E. taurica.
A. adsurgens.....E. polygoni and M. euphorbiae.
* " .....M. alni.
A. alpinus..... .....S. humuli var. fuliginea.
A. baeticus, caespitosus, Canadensis, *caryocarpus.....E. polygoni.
*A. Cicer.....M. astragali.
A. Cooperi.....M. euphorbiae.
*A. decumbens.....E. polygoni.
A. Drummondii.....M. euphorbiae.
A. frigidus var. Americanus, Gebleri.....E. polygoni,
A. Glycyphyllos..... .....M. astragali.
A. *Glycyphyllos, *hypoglottis, *junceus, Lamberti.....E. polygoni.
A. Mortoni.....M. euphorbiae.

*A. multiflorus.....E. polygoni.
*A. Onobrychis.....M. astragali.
A. oroboides var. Americanus, reflexistipulus, *triphyllus, irrigatus.....E. polygoni.
Avena *fatua, sativa.....E. graminis.
Ballota nigra.....E. galeopsidis.
* " " .....E. cichoracearum.
Balsamorhiza sagittata..... "
Baptisia tinctoria.....E. polygoni.
Bartsia Odontites.....S. humuli var. fuliginea.
Beckmannia erucaeformis.....E. graminis.
*Bellis annua.....E. tortilis.
Berberis Aquifolium .....M. berberidis.
B. vulgaris.....M. berberidis and P. corylea.
Betula alba.....M. alni and P. corylea.
* " " .....U. salicis.
B. lenta, lutea.....M. alni.
B. *lutea, nana, nigra, occidentalis, papyracea.....P. corleay.
*B. pumila .....M. alni.
Bidens cernua, chrysanthemoides, connata, frondosa, tripartita.S. humuli var. fuliginea.
Bigelowia graveolens and var. albicaulis.....E. polygoni var. sepulta.
B. viscidiflora.....E. cichoracearum.
Boltonia asteroides..... "
Borago officinalis ..... "
Brassica Rapa, *Sinapistrum, *sinapoides.....E. polygoni.
Breynia acuminata ..... "
Bromus *asper, breviaristatus, *Madritensis, *mollis, rubens, *secalinus, sterilis, *tectorum, *unioloides.....E. graminis.
Broussonetia papyrifera.....P. corylea.
*Buxus sempervirens..... "
* " " .....U. salicis.
Calamintha Chinensis..... .....S. humuli var. fuliginea.
Calendula arvensis..... " "
* " " .....E. polygoni.
C. officinalis..... .....S. humuli var. fuliginea.
* " .....E. cichoracearum.
* " .....E. polygoni.
Caltha palustris ..... "
* " " .....S. "Castagnei."
Calystegia Sepium.....E. polygoni.
*Campanula glomerata .....E. cichoracearum.
C. rapunculoides .....E. polygoni.
Capparis spinosa.....E. taurica.
Capsella Bursa-pastoris.....E. polygoni.
Caragana arborescens ..... "
Cardamine sp. ....E. cichoracearum.
Carduus sp. .....E. polygoni.

C. acanthoides.....E. cichoracearum.
*C. crispus.....E. taurica.
C. *tenuiflorus, *viridis.....E. cichoracearum.
*Carlina acaulis..... "
C. corymbosa, lanata.....E. taurica.
*C. vulgaris.....S. "Castagnei."
Carpesium abrotanoides.....S. humuli var. fuliginea.
Carpinus Americana.....P. corylea.
* " " .....M. alni.
C. Betulus.....P. corylea.
Carthamus lanatus.....E. taurica.
*Carum Persicum.....E. polygoni.
*Carya sp.....P. corylea.
C. alba, sulcata.....M. alni.
*Cassia Chamaecrista.....E. polygoni.
*Castanea dentata.....M. alni.
* " " .....P. corylea.
C. sativa, and var. Americana.....P. corylea and M. alni.
" var. Japonica.....M. alni.
Catalpa bignonioides, speciosa.....M. alni var. vaccinii and P. corylea.
C. syringaefolia.....E. polygoni.
Caucalis Japonica..... "
Ceanothus Americanus.....M. alni.
Celastrus articulatus.....U. Sengokui.
C. scandens.....P. corylea.
* " .....M. alni.
Celtis Americana.....U. parvula.
C. Mississippiensis.....U. polychaeta.
C. occidentalis.....U. polychaeta, U. parvula, and S. phytoptophila.
* " .....U. confusa.
C. tala.....U. polychaeta.
Centaurea *Jacea, nigra, nigrescens, Scabiosa.....E. cichoracearum.
*C. Scabiosa.....E. polygoni.
Cephalanthus occidentalis.....M. alni and P. corylea.
*Cerinthe major.....E. taurica.
*C. minor.....E. cichoracearum.
Chaerophyllum aromaticum, aureum, *bulbosum, hirsutum, *nodosum, temulum, *Villarsii.....E. polygoni.
Chelone glabra.....E. galeopsidis.
* " " .....E. polygoni.
* " " .....P. corylea.
Chelonopsis moschata.....E. galeopsidis.
*Chionanthus Virginica.....P. corylea.
Chondrilla juncea.....E. taurica.
Chrysopsis villosa.....E. cichoracearum.
*Cicer Songaricum.....E. taurica.

Cichorium Intybus.....E. cichoracearum.
* " " .....S. "Castagnei."
*Cicuta virosa.....E. polygoni.
*Cimicifuga foetida..... "
Circaea Lutetiana..... "
Clematis alpina and *var. Sibirica, Flammula, fusca var. Yezoensis, *integrifolia, *leucantha, *ligusticifolia..... "
*C. orientalis.....E. cichoracearum.
C. recta. .....E. polygoni.
C. Songarica.....E. taurica.
C. Virginiana, Vitalba .....E. polygoni.
*C. Vitalba.....P. corylea.
Cnicus altissimus, and var. discolor, *arvensis.....E. cichoracearum.
*C. arvensis.....E. taurica
C. Carduncul us..... "
C. *Cardunculus, eriophorus, heterophyllus, lanceolatus.....E. cichoracearum.
C. lanceolatus .....E. polygoni.
* " .....E. taurica.
C. oleraceus, *rivularis, undulatus and var. canescens.....E. cichoracearum.
C. Weyrichii var. Grayanum.....S. humuli var. fuliginea.
*Coccinea dubia.....E. taurica.
*Colliguaja Brasiliensis.....P. corylea.
Collomia gracilis, heterophylla, linearis.....S. humuli.
*C. linearis.....S. humuli var. fuliginea.
Colutea arborescens .....M. euphorbiae and E. polygoni.
C. cruenta.....M. euphorbiae.
*Conium maculatum.....E. polygoni.
Convolvulus Ammannii, arvensis, sagittatus..... "
Coreopsis aristosa, *aurea, tripteris.....S. humuli var. fuliginea.
*Cornus alba.....E. tortilis.
C. alternifolia.....M. alni.
C. Amomum..... .....P. corylea.
* " .....M. alni.
C. *candidissima, *circinata, florida.....P. corylea
C. macrophylla.....M. alni.
C. Mas, Nuttallii, sanguinea.....P. corylea.
C. sanguinea.....E. tortilis.
C. stolonifera .....P. corylea
* " .....M. alni.
Coronilla *Emerus, *varia .....E. polygoni.
Corylus Americana.....M. alni and P. corylea.
C. Avellana and var. laciniata, Colurna, rostrata .....P. corylea.
C. rostrata and var. Mandshurica.....M. alni.
C. tubulosa.....P. corylea.
Cotoneaster sp..... "
Cotyledon Semenovii.....M. umbilici.
*Cousinia uncinata.....E. cichoracearum.
*Crambe Sewerzowi.....E. polygoni.

*Crataegus sp. ..... U. prunastri.
C.*Azarolus, coccinea ..... P. oxyacanthae.
C. coccinea ..... P. corylea.
C. Crus-galli ..... P. oxyacanthae.
* " occidentalis ..... P. corylea.
C. Oxyacantha, rivularis, *sanguinea ..... P. corylea and P. oxyacanthae.
C. spathulata, *subvillosa, tomentosa ..... P. oxyacanthae.
C. tomentosa ..... P. corylea.
" var. punctata ..... P. oxyacanthae.
" var. pyrifolia ..... " and P. corylea.
Crepis paludosa ..... S. humuli var. fuliginea.
C. *paludosa, parviflora ..... E. cichoracearum.
C. runcinata ..... S. humuli var. fuliginea.
*C. tectorum ..... S. "Castagnei."
Crupina vulgaris ..... E. cichoracearum.
*Cucumis sativus ..... S. "Castagnei."
* " " ..... E. polygoni.
*Cucurbita maxima ..... S. "Castagnei."
C. Pepo ..... E. cichoracearum.
* " ..... E. polygoni.
* " ..... E. "Castagnei."
Cuphea viscosissima ..... E. polygoni.
Cynara Cardunculus ..... E. taurica.
Cynoglossum Morisoni, officinale ..... E. cichoracearum.
*Cytisus purpureus ..... E. polygoni.
Dactylis glomerata ..... E. graminis.
*Dahlia ..... E. cichoracearum.
* " ..... E. polygoni.
Daphne alpina ..... "
Daucus grandiflorus ..... "
D. maximus ..... E. taurica.
Delphinium Ajacis, *azureum, consolida, elatum, formosum, *grandiflorum, orientale, *Tiroliense, vestitum ..... E. polygoni.
*Deschampsia caespitosa ..... E. graminis.
Desmanthus brachylobus ..... E. polygoni.
Desmodium Canadense ..... M. diffusa.
* " " ..... P. corylea.
D. *canescens, *cuspidatum, paniculatum, sessilifolium ..... M. diffusa.
*Diarthron vesiculosum ..... E. taurica.
Diervilla Japonica ..... E. polygoni.
Dimorphotheca pluvialis ..... S. humuli var. fuliginea.
*Diospyros Virginiana ..... P. oxyacanthae.
*Diplotaxis tenuifolia ..... E. polygoni.
*Dipsacus Fullonum ..... S. "Castagnei."
D. laciniatus ..... S. humuli and E. polygoni.
D. sylvestris ..... S. humuli.

* " ..... E. polygoni.
Doronicum Austriacum, *grandiflorum ..... S. humuli var. fuliginea.
*Dorycnium herbaceum ..... E. taurica.
Draba alpina var. glacialis, hirta ..... S. humuli var. fuliginea.
*D. hirta ..... E. polygoni.
D. incana ..... S. humuli var. fuliginea.
Dysodia *chrysanthemoides, *papposa ..... E. cichoracearum.
Echinospermum *Lappula, *Redowskii, Virginicum ..... "
*Echium Italicum ..... "
E. vulgare ..... E. polygoni.
* " ..... E. cichoracearum.
Elaeoselinum Lagascae ..... E. taurica.
Ellisia Nyctelea ..... E. cichoracearum.
*Elsholtzia sp ..... P. corylea.
E. cristata ..... E. polygoni.
*Elymus condensatus ..... E. graminis.
Epigaea repens ..... M. alni var. vaccinii
Epilobium adenocaulon, alpinum ..... S. humuli.
*E. angustifolium ..... S. "Castagnei."
* " ..... U. salicis.
E. cephalostigma, coloratum, hirsutum, jucundum, montanum, palustre, parviflorum, parviflorum × roseum, pubescens, roseum ..... S. humuli.
*E. tetragonum ..... S. "Castagnei."
* " ..... E. cichoracearum.
Erechtites praealta ..... S. humuli var. fuliginea.
* " " ..... E. polygoni.
Erigeron acris, annuus ..... S. humuli var. fuliginea.
*E. armerifolius ..... E. cichoracearum.
E. Canadensis ..... S. humuli var. fuliginea.
E. *corymbosus, *divaricatus, elatus, *glabellus, macranthus, *strigosus ..... E. cichoracearum.
Eriogonum nudum ..... E. cichoracearum.
Erodium moschatum ..... S. humuli.
Eryngium campestre ..... E. taurica.
E. macrocalyx ..... E. polygoni.
*E. Noëanum ..... E. taurica.
Erysimum *cheiranthoides, *odoratum ..... E. polygoni.
Erythrina sp ..... P. corylea.
Eugenia sp ..... U. australis.
Euonymus atropurpureus ..... M. alni.
E. Europaeus ..... M. euonymi.
* " ..... P. corylea.
*E. verrucosus ..... M. euonymi.
Eupatorium ageratoides ..... E. ? galeopsidis.
E. cannabinum ..... E. cichoracearum.
* " ..... S. "Castagnei."
E. perfoliatum, purpureum ..... E. cichoracearum.
Euphorbia corollata ..... M. euphorbiae.

E. dulcis, helioscopia.....S. mors-uvae.
E. hypericifolia.....M. euphorbiae.
E. lanata.....E. taurica.
*E. marginata.....M. euphorbiae.
E. palustris, Peplus, platyphyllos.....S. mors-uvae.
E. Preslii.....M. euphorbiae.
E. stricta, *virgata.....S. mors-uvae.
Euphrasia officinalis.....S. humuli var. fuliginea.
*Exochorda Alberti.....E. taurica.
Fagopyrum esculentum.....E. polygoni.
Fagus *atropunicea, ferruginea.....M. alni.
*F. ferruginea.....P. corylea.
F. sylvatica..... "
Falcaria vulgaris.....E. polygoni.
*Falcata comosa..... "
Fatoua pilosa, var. subcordata.....S. humuli var. fuliginea.
Festuca *arundinacea, elatior, *gigantea, *heterophylla.....E. graminis.
Foeniculum vulgare.....E. taurica.
Forestiera acuminata.....M. alni.
Fragaria sp.....P. corylea.
F. glauca.....S. humuli.
* " .....S. humuli var. fuliginea.
Fraxinus Americana, excelsior and var. diversifolia.....P. corylea.
F. longicuspis.....U. fraxini.
F. Mandshurica, Ornus, *oxyphylla, pubescens, quadrangulata, sambucifolia, viridis.....P. corylea.
Gaillardia aristata.....S. humuli var. fuliginea.
* " " .....E. cichoracearum.
Galeopsis Tetrahit, versicolor.....E. galeopsidis.
Galium Aparine.....E. cichoracearum.
* " " .....E. polygoni.
G. boreale.....E. cichoracearum.
* " .....E. polygoni.
G. *Mollugo, *sylvaticum.....E. polygoni.
G. triflorum.....E. cichoracearum.
Gaylussacia resinosa.....M. alni var. vaccinii.
Geranium caespitosum, Carolinianum.....S. humuli.
*G. dissectum.....S. "Castagnei."
* " .....E. polygoni.
G. ibericum, incisum, maculatum.....S. humuli.
G. maculatum, *molle.....E. polygoni.
*G. molle.....S. "Castagnei."
G. nepalense, palustre, *pratense.....S. humuli.
G. *pratense, *pusillum *Pyrenaicum.....E. polygoni.
G. Richardsonii.....S. humuli.
* " .....E. polygoni.
G. sylvaticum.....S. humuli.
* " *tuberosum.....E. polygoni.
Gerardia grandiflora, quercifolia.....S. humuli var. fuliginea.

Geum album, Kokanicum, *macrophyllum, strictum.....S. humuli.
G. urbanum .....E. polygoni.
* " .....E. cichoracearum.
G. Virginianum .....S. humuli.
Gilia aristella, heterophylla, linearis..... "
Gleditschia triacanthos .....M. alni.
Glyceria *aquatica, *nervata.....E. graminis.
Glycyrrhiza lepidota .....M. diffusa.
Gnaphalium sylvaticum.....E. cichoracearum.
Grindelia squarrosa ..... "
Gundelia Tournefortii .....E. taurica.
Gutierrezia Euthamiae.....E. cichoracearum.
* " " .....E. polygoni.
Gymnocladus sp .....M. alni.
Gypsophila Gmelini.....E. polygoni
Haloxylon Ammodendron.....E. taurica.
Hamamelis Japonica .....P. corylea.
H. Virginiana.....P. biuncinata.
* " .....P. corylea.
*Haplophyllum Sieversianum.....E. taurica.
Hedysarum Falconeri.....E. taurica.
Helenium autumnale.....E. cichoracearum.
*Helianthella Parryi..... "
Helianthemum Oelandicum.....E. taurica.
H. vulgare.....S. humuli var. fuliginea.
Helianthus annuus, *Californicus, and var. *Utahensis, doronicoides, giganteus, *grosseserratus, Maximiliani, orgyalis, petiolaris, rigidus, strumosus, tuberosus, and var. subcanescens.....E. cichoracearum.
Helichrysum arenarium..... "
Heracleum asperum, *flavescens, palmatum, Sibiricum, Sphondylium.....E. polygoni.
Hesperis matronalis, *tristis..... "
*Heuchera Americana..... "
*H. parvifolia.....P. corylea.
* " .....S. "Castagnei."
Hieracium sp.....S. humuli var. fuliginea.
H. albiflorum, *boreale, *Canadense, *incisum, lycopsifolium, *murorum, prenanthoides.....E. cichoracearum.
*H. sabaudum.....S. "Castagnei."
* " *vulgatum.....E. cichoracearum.
Hippophaë rhamnoides.....P. corylea.
*Holcus mollis.....E. graminis.
Hordeum *jubatum, *murinum, secalinum, vulgare..... "
Hosackia parviflora.....E. polygoni.
Humulus Japonicus, Lupulus.....S. humuli.
*H. Lupulus.....E. cichoracearum.
* " .....P. corylea.
Hydrophyllum appendiculatum.....

H. Canadense, capitatum, *macrophyllum, *occidentale, Virginicum ..... E. cichoracearum.
H. Virginicum..... S. humuli var. fuliginea.
Hyoscyamus albus, niger..... E. cichoracearum.
*H. niger..... E. polygoni.
Hypericum atomarium, hirsutum..... "
*H. humifusum..... E. cichoracearum.
H. montanum, perforatum, quadrangulum..... E. polygoni.
Ilex decidua..... P. corylea and M. alni.
I. *mollis, *verticillata..... M. alni.
Impatiens balsamina..... S. "Castagnei."
I. noli-tangere, textori..... S. humuli var. fuliginea.
*Inula Britannica..... E. cichoracearum.
I. dysenterica..... S. humuli var. fuliginea.
I. *Helenium, hirta..... E. cichoracearum.
I. nervosa..... E. taurica.
I. Oculus-Christi, salicina..... E. cichoracearum.
*I. salicina..... E. polygoni.
*Isatis tinctoria..... "
Iva *frutescens, *xanthifolia..... E. cichoracearum.
Johrenia sp..... E. polygoni.
*Juglans sp..... P. corylea.
J. cinerea, nigra..... M. alni.
Kuhnia eupatorioides..... E. cichoracearum.
Laburnum vulgare..... M. guarinonii.
Lactuca brevirostris, *Floridana..... S. humuli var. fuliginea.
*L. muralis..... E. cichoracearum.
* " ..... E. polygoni.
*L. pulchella..... E. cichoracearum.
L. Raddiana..... S. humuli var. fuliginea.
L. Scariola..... E. cichoracearum.
L. Sibirica..... S. humuli var. fuliginea.
*L. viminea..... E. cichoracearum.
Lagerstroemia Indica, ovalifolia..... U. Australiana.
Lamium album, *amplexicaule, galeobdolon, *intermedium, maculatum, purpureum..... E. galeopsidis.
Laportea bulbifera..... E. cichoracearum.
*Lapsana communis..... E. cichoracearum.
* " " ..... S. "Castagnei."
Lathyrus Aphaca, *montanus, *Nissolia..... E. polygoni.
L. ochroleucus..... M. alni.
* " ..... M. diffusa.
*L. palustris..... M. alni.
L. pisiformis, *polymorphus, polyphyllus, pratensis..... E. polygoni.
L. pratensis..... M. alni.
L. tuberosus, uliginosus, venosus..... E. polygoni.
L. venosus..... M. alni.
Leontodon autumnalis..... S. humuli var. fuliginea.
Leonurus Cardiaca..... E. galeopsidis.

Lespedeza capitata, hirta, striata.....M. diffusa.
*L. striata.....E. polygoni.
L. violacea.....M. diffusa.
Ligustrum medium.....M. alni.
*Linaria genistifolia.....E. polygoni.
*L. vulgaris.....S. "Castagnei."
Liriodendron Tulipifera.....P. corylea and E. polygoni.
Lithospermum arvense.....E. cichoracearum.
* " " .....E. polygoni.
L. officinale.....E. cichoracearum.
*Lolium perenne.....E. graminis.
Lonicera alpigena.....M. alni var lonicerae.
L. caerulea.....M. alni var. divaricata.
L. Caprifolium.....M. alni var. lonicerae.
" .....P. corylea.
L. flava.....M. alni and var. lonicerae.
L. glauca, glaucescens, *hirsuta.....M. alni.
L. *hispida, implexa.....M. alni var. lonicerae.
L. involucrata.....M. alni.
L. lutea, nigra.....M. alni var. lonicerae.
L. oblongifolia, parviflora.....M. alni.
L. Periclymenum.....M. alni var. lonicerae.
L. sempervirens, *Sullivantii.....M. alni.
L. tatarica, Xylosteum.....M. alni var. lonicerae.
L. Xylosteum.....P. corylea.
Lophanthus anisatus.....S. humuli var. fuliginea.
Lotus *corniculatus, *major, Purshiana.....E. polygoni.
*Lunaria rediviva..... "
Lupinus albus, *angustifolius, *argenteus, var. argophyllus, laxiflorus, luteus, parviflorus, perennis, sericeus..... "
Lychnis *alba, dioica, *sylvestris..... "
Lycium barbarum, Europaeum, *ovatum.....M. Mougeotii.
*L. ovatum.....L. "Castagnei."
*L. Ruthenicum.....M. Mougeotii.
Lycodesmia juncea.....E. cichoracearum.
*Lycopersicum esculentum.....E. polygoni.
Lycopsis arvensis..... "
* " " .....E. cichoracearum.
Lycopus Europaeus..... "
*Lyonia paniculata.....M. alni and var. vaccinii.
Lygodesmia juncea.....E. cichoracearum.
Lythrum Salicaria.....E. polygoni.
Madia glomerata.....E. cichoracearum.
Magnolia *acuminata, *Fraseri, Kobus.....P. corylea.
*Malcomia maritima.....E. polygoni.
Marrubium vulgare.....E. galeopsidis.
Medicago falcata, lupulina, sativa.....E. polygoni.
Melampyrum nemorosum, pratense, sylvaticum.....S. humuli var. fuliginea.

Melilotus alba, officinalis ..... E. polygoni.
Menispermum Canadense ..... M. alni.
Mentha aquatica, arvensis ..... E. cichoracearum.
Mercurialis perennis ..... P. corylea.
Mertensia maritima, Sibirica ..... E. cichoracearum.
Microseris aphantocarpha ..... S. humuli var. fuliginea.
*Mikania scandens ..... E. cichoracearum.
*Milium effusum ..... E. graminis.
*Mimulus luteus ..... E. cichoracearum.
Morina Persica ..... S. humuli.
Morus alba ..... P. corylea.
M. rubra ..... U. geniculata.
Myosotis *intermedia, *sparsiflora, *sylvatica ..... E. cichoracearum.
Myrrhis odorata ..... E. polygoni.
Napaea dioica ..... E. cichoracearum.
*Negundo aceroides ..... P. corylea.
Neillia opulifolia ..... S. humuli.
Nemopanthus fascicularis ..... M. alni.
Nepeta podostachys ..... E. taurica.
Nicotiana Tabacum ..... E. cichoracearum.
Nyssa sp. ..... P. corylea.
Odontospermum aquaticum ..... E. taurica.
OEnothera albicaulis, biennis, *sinuata ..... E. polygoni.
*Olea Europaea ..... P. corylea.
*Onobrychis viciaefolia ..... E. polygoni.
Ononis arvensis, *hircina, repens, spinosa ..... "
*Onopordon Acanthium ..... E. cichoracearum.
*Onosma simplicissimum ..... "
Orobus lathyroides ..... E. polygoni.
Ostrya Virginica ..... U. macrospora, M. alni and P. corylea.
Oxalis corniculata, var. stricta, Suksdorfii, *violacea ..... M. Russellii.
Oxytropis Lamberti ..... E. polygoni.
Paeonia obovata, officinalis, peregrina ..... "
Paliurus aculeatus ..... P. corylea.
*Panicum sanguinale ..... E. graminis.
Parietaria *debilis, *officinalis, Pennsylvanica ..... E. cichoracearum.
Parmentiera alata ..... P. corylea.
Parnassia Caroliniana ..... E. polygoni.
Paulownia imperialis ..... P. corylea.
Pedicularis cheilanthifolia ..... S. humuli var. fuliginea.
*P. foliosa ..... S. "Castagnei."
P. Groenlandica, lanceolata, pycnantha, resupinata ..... S. humuli var. fuliginea.
*P. resupinata ..... E. polygoni.
Peganum Hamala ..... E. taurica.
*Pentstemon barbatus ..... S. "Castagnei."
Peucedanum *Alsaticum, *Cervaria, Oreoselinum, sativum, terebinthaceum ..... E. polygoni.
Phacelia circinata, Menziesii ..... E. cichoracearum.

*Phaseolus helvolus.....E. polygoni.
P. perennis.....M. diffusa.
* " .....E. polygoni.
Philadelphus Lewisii.....P. corylea.
*Phillyrea media.....U. aceris.
*Phleum pratense.....E. graminis.
Phloiodocarpus Dahuricus.....E. polygoni.
Phlomis Herba-venti.....E. taurica.
* " " .....E. galeopsidis.
P. tuberosa.....E. cichoracearum.
* " .....E. taurica.
Phlox divaricata.....E. cichoracearum.
* " " .....S. humuli var. fuliginea.
*P. Drummondii.....E. cichoracearum.
P. longifolia.....S. humuli.
P. paniculata.....E. cichoracearum.
Physalis Alkekengi.....S. humuli var. fuliginea.
Physospermum commutatum.....E. polygoni.
Picrasma quassioides.....M. alni.
Picris hieracioides.....E. taurica.
* " " .....E. polygoni.
*Pilea pumila.....E. cichoracearum.
P. stipulosa.....E. polygoni.
Pimpinella magna, Saxifraga..... "
Pisum sativum..... "
Plantago Bellardi, *Coronopus, Kamtschatica, Lagopus, lanceolata .....E. cichoracearum.
P. lanceolata .....S. humuli var. fuliginea.
P. major, and var. Asiatica.....E. cichoracearum.
* " .....S. "Castagnei."
P. maritima, media.....E. cichoracearum.
P. media.....S. humuli var. fuliginea.
*P. Psyllium.....E. cichoracearum.
Platanus occidentalis.....M. alni.
* " " .....S. "Castagnei."
Poa annua, Buckleyana, bulbosa, nemoralis, pratensis, serotina, *Sinaica, tenuifolia, trivialis .....E. graminis.
Polygonum aviculare, dumetorum, lapathifolium, *Persicaria, ramosissimum and var. *prolificum .....E. polygoni.
Populus alba, *angustifolia, balsamifera and var. candicans, ciliata, grandidentata, heterophylla, monilifera, nigra, pyramidalis, tremula, tremuloides, trichocarpa.....U. salicis.
*Potentilla sp.....E. polygoni.
P. Anserina.....S. humuli.
*P. approximata .....S. "Castagnei."
P. bifurca.....S. humuli.
* " .....E. cichoracearum.
P. Comarum, fragarioides, glandulosa, palustris .....S. humuli.
*P. Pennsylvanica.....S. "Castagnei."

P. reptans, Tormentilla.....S. humuli.
*P. viscosa.....E. cichoracearum.
Poterium Canadense and var. medium, officinale, and var. carneum.....S. humuli.
*P. Sanguisorba.....S. "Castagnei."
P. Sitchense (cult.), tenuifolium and var. album.....S. humuli.
*Prenanthes alba.....S. humuli var. fuliginea.
* " " .....E. cichoracearum.
P. *altissima, purpurea.....S. humuli var. fuliginea.
P. purpurea.....E. cichoracearum.
* " .....E. polygoni.
Prunella vulgaris.....S. humuli var. fuliginea.
* " " .....E. cichoracearum.
Prunus Americana.....P. oxyacanthae.
* " " .....P. corylea.
P. Armeniaca.....P. oxyacanthae var. tridactyla.
P. Avium.....P. oxyacanthae.
* " .....P. corylea.
P. Besseyi.....P. oxyacanthae.
P. Cerasus.....P. corylea and P. oxyacanthae.
*P. Chicasa.....P. oxyacanthae.
P. communis.....P. oxyacanthae var. tridactyla.
P. demissa, domestica.....P. oxyacanthae.
P. domestica, insititia.....P. oxyacanthae var. tridactyla.
P. insititia.....U. prunastri.
*P. Mahaleb.....P. "Kunzei."
P. Padus.....P. oxyacanthae var. tridactyla.
*P. Pennsylvanica.....P. oxyacanthae.
P. Persica.....S. pannosa.
* " .....P. oxyacanthae.
P. pumila.....U. prunastri and P. oxyacanthae.
P. serotina.....P. oxyacanthae.
P. spinosa.....P. oxyacanthae var. tridactyla and U. prunastri.
P. Virginiana.....P. oxyacanthae.
Psoralea drupacea.....E. taurica.
*P. tenuiflora.....E. polygoni.
Pulmonaria mollis, officinalis.....E. cichoracearum.
Pyrus amygdaliformis.....P. corylea.
P. Aria.....S. humuli.
P. Aucuparia.....P. oxyacanthae.
* " .....P. oxyacanthae var. tridactyla.

P. communis.....P. corylea.
P. *coronaria, Cydonia, Germanica.....P. oxyacanthae.
P. Germanica.....P. corylea.
P. Malus.....P. leucotricha and P. oxyacanthae.
P. Sieboldi.....P. leucotricha.
*P. torminalis.....P. corylea.
Quercus agrifolia.....S. lanestris and E. trina.
Q. alba.....M. alni and var. extensa.
* " .....S. lanestris.
Q. aquatica.....M. alni and var. calocladophora and P. corylea.
Q. bicolor, and × macrocarpa, and × Michauxii, Catesbaei..M. alni.
Q. Catesbaei, *coccifera.....P. corylea.
Q. coccinea and var. tinctoria .....M. alni and P. corylea.
Q. crispula, dentata.....M. alni.
Q. discolor .....P. corylea and M. alni var. extensa.
Q. falcata .....M. alni and P. corylea.
Q. glauca .....E. polygoni.
Q. Ilex .....P. corylea.
*Q. ilicifolia .....M. alni or var. extensa.
Q. imbricaria .....M. alni.
Q. Kelloggii.....P. corylea.
Q. laurifolia .....M. alni var. calocladophora.
Q. lyrata, macrocarpa .....M. alni.
Q. macrocarpa .....S. lanestris and P. corylea.
*Q. minor .....S. lanestris.
Q. nigra .....M. alni and vars. extensa and calocladophora and P. corylea.
Q. obtusiloba .....M. alni.
Q. palustris .....M. alni var. extensa and P. corylea.
Q. Phellos .....M. alni.
* " .....P. corylea.
Q. Prinus .....M. alni and S. lanestris.
Q. Robur .....P. corylea and M. alni.
Q. rubra .....M. alni and var. extensa and P. corylea.
* " S. lanestris.
Ranunculus abortivus, *aconitifolius, acris, arvensis, *Asiaticus, bulbosus, Cymbalaria, Flammula,* lanuginosus, *Lingua, *macranthus, montanus, multifidus, Pennsylvanicus, repens, sardous, *sceleratus, *septentrionalis, trachycarpus .....E. polygoni.
Rhamnus alpina.....P. corylea.

R. cathartica ..... M. alni.
* " ..... M. alni var. divaricata.
R. Frangula ..... M. alni var. divaricata.
Rhinanthus *angustifolius, *minor ..... S. "Castagnei."
Rhododendron sp. ..... P. corylea.
R. nudiflorum ..... M. alni.
Rhus copallina, glabra, *typhina ..... S. humuli.
Ribes *cereum, Cynosbati ..... S. mors-uvae.
R. Cynosbati ..... P. corylea.
R. divaricatum var. irriguum, Floridanum ..... S. mors-uvae.
R. floridum ..... S. humuli.
* " ..... M. grossulariae.
R. *gracile, Grossularia ..... S. mors-uvae.
R. Grossularia ..... M. grossulariae and P. corylea.
R. Hudsonianum, lacustre ..... S. mors-uvae.
R. *Magellanicum ..... P. corylea.
R. Missouriense ..... S. mors-uvae.
*R. nigrum ..... M. grossulariae.
R. prostratum, rotundifolium ..... S. mors-uvae.
*R. rotundifolium ..... M. grossulariae.
R. rubrum ..... S. mors-uvae.
R. sanguineum ..... M. grossulariae.
Robinia *Pseudacacia, viscosa ..... E. polygoni.
*Rosa alba ..... S. pannosa.
R. Arkansana ..... S. humuli.
R. arvensis ..... S. pannosa.
R. blanda ..... S. humuli.
R. canina, centifolia, *cinnamomea, damascena, *dumetorum, *Eglanteria, Gallica, *glauca ..... S. pannosa.
R. lucida ..... S. humuli.
R. pomifera, *rubiginosa, tomentosa, villosa ..... S. pannosa.
R. Woodsii ..... S. humuli.
Rubus Canadensis ..... "
*R. "fruticosus" ..... P. corylea.
R. hispidus, odoratus, spectabilis, *strigosus, triflorus ..... S. humuli.
Rudbeckia hirta, *occidentalis ..... E. cichoracearum.
Rumex Acetosella ..... E. polygoni.
* " " ..... E. cichoracearum.
*R. Hydrolapathum ..... E. polygoni.
*Saccharum officinarum ..... E. graminis.
Salix sp. ..... P. corylea.
S. alba ..... U. salicis.
* " ..... P. Schlechtendalii.
S. *angustifolia, aurita, Caprea and var. pendula ..... U. salicis.
*S. Caprea ..... P. corylea.
S. cinerea, cordata, daphnoides, discolor, flavescens and var. Scouleriana, *fragilis, *glauca, humilis, *incana, livida, *longifolia, nigra and var. falcata, nigricans, petiolaris,

purpurea, *pyrolaefolia, repens, sericea, Seringiana, triandra, Urbaniana, viminalis.....U. salicis.
S. viminalis.....P. Schlechtendalii.
*Salsola canescens.....E. taurica.
*Salvia glutinosa.....E. cichoracearum.
*S. verticillata.....E. galeopsidis.
Sambucus Canadensis.....M. grossulariae.
* " " .....M. alni.
*S. nigra.....P. corylea.
S. racemosa and var. pubescens.....M. grossulariae.
Sanvitalia procumbens.....S. humuli var. fuliginea.
*Saussurea sp.....E. taurica.
S. salicifolia.....E. cichoracearum.
Saxifraga cortusaefolia.....E. polygoni.
*S. punctata.....S. "Castagnei."
S. rotundifolia.....S. humuli var. fuliginea.
Scabiosa arvensis..... " "
" " .....E. polygoni.
S. Caucasica.....S. humuli.
*S. integrifolia.....S. "Castagnei."
S. *stellata, *succisa, sylvatica.....E. polygoni.
Scandix Pecten-Veneris..... "
Schizandra Chinensis.....M. alni.
*Scorzonera sp.....S. "Castagnei."
S. *hirsuta, Hispanica, humilis.....E. cichoracearum.
*S. radians.....S. "Castagnei."
Scrophularia canina.....S. humuli var. fuliginea.
Scutellaria lateriflora.....E. cichoracearum, U. Columbiana.
* " " .....E. galeopsidis.
* " " .....E. polygoni.
S. multicaulis.....E. taurica.
*S. parvula.....E. galeopsidis.
S. scordiifolia.....E. polygoni.
*Secale cereale.....E. graminis.
Selinum carvifolium.....E. polygoni.
Senecio Cacaliastrum, cordatus, Fuchsii.....S. humuli var. fuliginea.
S. hydrophilus.....E. cichoracearum.
*S. Jacobaea.....S. "Castagnei."
S. lugens.....S. humuli var. fuliginea.
*S. lyratifolius.....S. "Castagnei."
S. nemorensis. sarracenicus.....S. humuli var. fuliginea.
*S. spathulaefolius.....S. "Castagnei."
S. subalpinus.....S. humuli var. fuliginea.
S. sylvaticus.....E. cichoracearum
* " .....S. "Castagnei."
S. triangularis.....S. humuli var. fuliginea.
S. vulgaris.....E. cichoracearum.
* " .....S. "Castagnei."

*Sesbania sp.....E. cichoracearum.
*Seseli Libanotis.....E. polygoni.
*Sesleria caerulea.....E. graminis.
Shepherdia argentea, Canadensis.....S. humuli.
Siegesbeckia orientalis.....S. humuli var. fuliginea.
*Silaus flavescens.....E. polygoni.
*Silene noctiflora..... "
*Siler trilobum..... "
Silphium terebinthinaceum.....E. cichoracearum.
Sisymbrium *Alliaria, *officinale, Sophia.....E. polygoni.
Sium erectum, *latifolium.....E. polygoni.
*Smyrnium Olusatrum..... "
Solanum Carolinense.....E. cichoracearum.
Solidago Canadensis, *Missouriensis, nana, *occidentalis, *rigida, serotina.....E. cichoracearum.
Sonchus arvensis..... "
* " " .....E. polygoni.
S. asper, oleraceus.....E. cichoracearum.
*Spartium junceum.....E. polygoni.
Spiraea Aruncus.....S. humuli.
S. betulifolia.....P. oxyacanthae.
S. Camtschatica.....S. humuli.
*S. discolor.....P. oxyacanthae.
S. Douglasii.....P. oxyacanthae var. tridactyla.
*S. Filipendula.....S. "Castagnei."
S. salicifolia.....P. oxyacanthae.
* " Thunbergii.....S. humuli.
S. tomentosa.....P. oxyacanthae.
S. Ulmaria.....E. polygoni and S. humuli.
Stachys alpina, aspera and vars. *glabra and Japonica, ciliata and var. pubens, *cordata, Germanica, melissaefolia, palustris.....E. galeopsidis.
*S. palustris.....E. cichoracearum.
S. sylvatica.....E. galeopsidis.
Statice Gmelini, Limonium.....E. polygoni.
Stevia sp.....E. cichoracearum.
Symphoricarpos occidentalis, orbiculatus, racemosus and var. *pauciflorus.....M. diffusa.
Symphytum officinale.....E. cichoracearum.
* " " .....E. polygoni.
S. tuberosum.....E. cichoracearum.
Syringa Amurensis var. Japonica, *Persica, vulgaris.....M. alni.
*S. vulgaris.....M. alni var. lonicerae.
* " .....P. corylea.
Tanacetum vulgare.....E. cichoracearum and P. corylea.
Taraxacum montanum.....E. taurica.

T. officinale ..... S. humuli var. fuliginea.
* " ..... E. cichoracearum.
Tecoma radicans ..... M. alni.
* " " ..... E. cichoracearum.
Tellima grandiflora ..... S. humuli var. fuliginea.
Teucrium Canadense ..... E. galeopsidis.
* " " ..... E. cichoracearum.
T. Chamaedrys ..... E. taurica.
* " ..... E. cichoracearum.
* " ..... E. polygoni.
Thalictrum alpinum ..... S. humuli var. fuliginea.
T. *angustifolium, aquilegiifolium, Cornuti, flavum, minus and var. elatum, simplex ..... E. polygoni.
*T. simplex ..... S. "Castagnei."
*Thelesperma filifolium ..... "
Thermopsis montana ..... E. polygoni.
Thesium *bavarum, *ebracteatum ..... "
*Thevenotia scabra ..... E. taurica.
*Thlaspi arvense ..... E. polygoni.
Thymelaea sp. ..... E. taurica.
Tilia Americana ..... U. Clintonii.
*Tragopogon sp. ..... E. polygoni.
T. porrifolius, pratensis ..... E. cichoracearum.
*Trifolium sp. ..... S. "Castagnei."
T. *agrarium, alpestre, arvense, filiforme, hybridum, incarnatum, involucratum, longipes, Lupinaster, medium, *minus, *monanthum, montanum, moranthum, pauciflorum, pratense, procumbens, *repens, rubens. ..... E. polygoni.
*Trigonella sp ..... E. cichoracearum.
T. Cretica, Foenum-graecum ..... E. polygoni.
Triticum sativum, Spelta, vulgare ..... E. graminis.
Trollius Europaeus ..... E. polygoni.
Troximon glaucum, *officinalis ..... S. humuli var. fuliginea.
*Typha latifolia ..... P. corylea.
Ulmus alata ..... U. macrospora and P. corylea.
U. Americana ..... M. macrospora, P. corylea, and M. alni.
U. campestris ..... U. clandestina and P. corylea.
U. fulva ..... U. macrospora.
U. montana ..... U. clandestina and P. corylea.
*Urtica sp ..... S. "Castagnei."
U. cannabina, dioica, *urens ..... E. polygoni.
Vaccinium Canadense ..... M. alni var. vaccinii.
V. corymbosum ..... M. alni.
V. *intermedium, Myrtillus ..... P. oxyacanthae.
V. Myrtillus vars. macrophyllum and *microphyllum, Pennsylvanicum ..... M. alni var. vaccinii.

V. stamineum.....P. corylea.
V. uliginosum.....P. oxyacanthae.
V. vacillans.....M. alni var. vaccinii.
*Valeriana capitata.....E. polygoni.
V. officinalis.....E. cichoracearum.
* " .....E. polygoni.
Valerianella *dentata, *rimosa.....E. polygoni.
Verbascum Blattaria.....E. taurica.
V. nigrum.....E. cichoracearum.
V. phlomoides.....E. taurica.
* " .....E. polygoni.
* " *pulverulentum.....E. cichoracearum.
V. speciosum .....E. taurica.
V. *thapsiforme, *Thapsus.....E. cichoracearum.
*V. Thapsus.....E. polygoni.
Verbena sp.....S. humuli var. fuliginea.
V. angustifolia, Aubletia, *bracteata, hastata .....E. cichoracearum.
V. hybrida.....M. ferruginea.
V. laevis, *officinalis, stricta, urticifolia .....E. cichoracearum.
*V. urticifolia.....E. galeopsidis.
* " .....E. polygoni.
Verbesina *encelioides, *occidentalis .....E. cichoracearum.
Vernonia Baldwini, fasciculata, Noveboracensis ..... "
*V. Noveboracensis.....S. humuli var. fuliginea.
Veronica longifolia, spicata..... " "
*V. Teucrium.....E. polygoni.
V. Virginica.....S. humuli var. fuliginea.
Viburnum acerifolium, dentatum, Lantana, Lentago, Opulus, prunifolium, pubescens, *Tinus.....M. alni.
*Vicia sp.....M. diffusa.
V. Americana and var. linearis.....M. alni and var. ludens.
V. *Americana and var. *ludens.....E. polygoni.
V. Americana var. truncata.....M. alni var. ludens.
V. cassubica.....M. Bäumleri.
V. *cassubica, Cracca, *Faba, *gemella, *hirsuta, oroboides, pallida, *sativa, sepium, sylvatica.....E. polygoni.
V. sylvatica.....M. Bäumleri.
V. tenuifolia.....E. taurica.
V. unijuga .....E. polygoni.
*Vincetoxicum officinale..... "
Viola Canadensis, canina var. sylvestris .....S. humuli.
*V. cucullata.....S. humuli var. fuliginea.
Vitis *aestivalis, *Californica, *cordifolia, flexuosa, hederacea, Labrusca and var. Catawba .....U. necator.
*V. Labrusca .....P. corylea.
V. *riparia, *rupestris, vinifera .....U. necator.
*V. vinifera .....S. "Castagnei."
Xanthium Canadense .....S. humuli var. fuliginea and E. cichoracearum.

X. Italicum, macrocarpum, spinosum, strumarium.....S. humuli var. fuliginea.
X. strumarium .....E. cichoracearum.
Xanthoxylum Americanum .....P. corylea.
Zelkova acuminata.....U. Clintonii and M. alni.
Zygophyllum Fabago .....E. taurica.

ERRATA.

Page 8, line 21, for "a basal," read "an apical."

Page 8, line 22, for "in the first place," read "subsequently."

Page 8, line 7 from bottom, insert comma after "shape," and for "occurs" read "occur."

Page 10, line 6, insert comma after "conidiophores."

Page 23, lines 17, 18, for "*Coumbiana*" read "*Columbiana*."

Page 27, line 5, insert comma after "interest"; line 18, insert comma after "notes," and delete comma at end of line; line 25, for "Ott's" read "Otth's"; line 36, for "Prof. A. Macacsy Diete" read "Prof. A. Magacsy Dietz."

Page 31, lines 9, 11, 12, for "*penicellata*" read "*penicillata*"; line 16, for "Enun" read "Fenn."

Page 32, line 31, read comma after "species."

Page 33, line 20, insert comma after "distinct," and "of" after "most."

Page 34, line 2 from bottom, for "periitheciis" read "peritheciis."

Page 36, line 18, for "Win." read "Wint."; line 22, for "Ouden." read "Oudem."; line 31, for "Brit." read "Bri."

Page 38, line 6, insert comma after "been."

Page 48, line 5, for "Roumig" read "Roumeg."

Page 49, line 4 from bottom, for "Ontaria" read "Ontario."

Page 50, line 8 from bottom, insert "Sacc." before "Syll. Fung."

Page 52, line 9, for "Hortm." read "Hartm."

Page 53, line 3, for "Cacatiastrum" read "Cacaliastrum."

Page 54, line 8, read comma after "species"; line 9 from bottom, delete comma after "measure"; line 6 from bottom, insert comma after "indicated," and carry parenthesis to end of sentence.

Page 55, line 2, for "largely" read "larger."

Page 56, line 14, for "fulginea" read "fuliginea"; line 10 from bottom, for "o" read "of."

Page 57, line 12 from bottom, for "aber" read "über" and for "art" read "Art."

Page 61, line 19, for "Verwandlschaft" read "Verwandtschaft"; line 7 from bottom, for "Auschauung" read "Anschauung"; line 5 from bottom, for "auftren" read "auftreten."

Page 62, line 3, for "shown on a house plant" read "sown on a host-plant";

Page 63, line 18, for "imperfect" read "infected."

Page 68, line 7, for "weil" read "weit"; line 15, for "nich" read "nicht"; line 21, insert "from" after "suffer."

Page 71, line 16 from bottom, for "Treub." read "Trent."

Page 79, line 15 from bottom, for "unattached" read "unattacked."

Page 84, line 18 from bottom, for "on *U. salicis*" read "of," etc.

Page 87, line 13, for "Oestergren" read "Vestergren."

Page 95, line 4 from bottom, for "Erw." read "Env."

Page 97, line 15, for "Le" read "Se."

Page 103, line 25, for "probably" read "possibly."

Page 103, line 28, for "attached" read "attacked."

Page 103, line 30, delete comma at end of line.

Page 103, line 31, for "or" read "of."

Page 108, line 20, for "or" read "on."

Page 109, line 13, for "forms" read "form."

Page 109, line 25, for "perisistent" read "persistent."

Page 117, line 1, delete comma after "*Uncinula*" and insert comma after "priority."

Page 117, line 18, for "grisecenti" read "grisescenti."

Page 117, line 24, delete comma after "gradatim."

Page 120, line 18, for "equally" read "equalling."

Page 121, line 3 from bottom, for "*E. communis*" read "*E. polygoni.*"

Page 122, line 4, insert "examined" after "specimens."

Page 123, line 16, insert comma after "branches."

Page 123, line 18, insert "with" after "apex."

Page 125, line 20, for "or" read "of."

Page 127, line 23, for "&" read "G."

Page 128, line 24, insert "to" after "related."

Page 135, line 8, replace semicolon after "*Microsphaera*" by comma.

Page 136, line 12 from bottom, for "indefinite" read "in definite."

Page 138, line 3 from bottom, for "fairly" read "faintly."

Page 139, line 10, insert "form" after "another."

Page 141, line 4, after "species" read "and observes of the plant."

Page 141, line 11, for "tips fill" read "tip fills."

Page 143, line 4 from bottom, for "Weerl" read "Neerl."

Page 148, line 6, for "*exclusa*" read "*extensa.*"

Page 148, line 11, insert comma after "*alni.*"

Page 150, line 10 from bottom, for "*E.*" read "*V.*"

Page 152, line 14, delete comma after "diameter."

Page 153, after line 8, insert synonymy and description of var. *calocladophora* (Atkins.) given at page 153, last three lines, and page 154, lines 1–10.

Page 158, line 9, delete comma after "half."

Page 160, line 2 from bottom, for "uses" read "use."

Page 162, line 24, for "possess" read "possesses."

Page 162, lines 29–30, for "necessay" read "necessary."

Page 164, last line, for "lips" read "tips."

Page 166, line 10. for "sightly" read "slightly."

Page 168, line 9 from bottom, for "3–2" read "3–5."

Page 170, line 5, for "seil" read "seit"; line 7, for "aufangs" read "anfangs"; line 17, for "un" read "im"; line 18, for "weinger" read "weniger"; line 20, for, "*P. Bäumleri*" read "*M. Bäumleri.*"

Page 171, line 6 from bottom, for "is" read "ist."

Page 172, line 8, for "*Mäumleri*" and "*Barchica*" read "*Bäumleri*" and "*Marchica.*"

Page 179, line 11, for "*glycyphyllosus*" read "*glycyphyllos*"; line 24, for "*yezoeüsis*" read "*yezoensis.*"

Page 180, line 14, for "*Nessolia*" read "*Nissolia.*"

Page 181, line 7, for "*Sseïe*" read "*Seseli.*"

Page 187, line 3, for "of" read "on"; line 5, delete comma after "*vernalis.*"

Page 192, line 21, insert "which" after "spores."

Page 195, line 7, for "knantiae" read "knautiae."

Page 204, line 10 from bottom, for "Passinini" read "Passerini."

Page 215, last line, for "*Erisyphe*" read "*Erysiphe.*"

Page 217, line 5, for "*Carinthe*" read "*Cerinthe*"; line 8, for "*Dorycinum*" read "*Dorycnium.*"

Page 225, line 7, for "*orbiculatus*" read "*orbicularis.*"

Page 233, line 2, insert "the" before "*Phyllactinia.*"

Page 234, line 6 from bottom, insert comma after "outgrowths."

Page 235, line 5, delete "again."

Page 236, line 15, for "soul" read "sont"; line 7 from bottom, insert period after "A."

Page 237, line 11, for "*radiens*" read "*radians*"; line 7 from bottom for "dout" read "dont."

Page 244, no. 77, for "Calmeiro" read "Colmeiro."

Page 246, no. 106, for "Hayl" read "Haye"; no. 111, for "Mycelogensi" read "Mycetogenesi"; no. 125, delete "Part 3."

Page 248, no. 160, for "*Sphraeo-*" read "*Sphaero-.*"

Page 250, last line, for "1858," read "1851."

Page 251, no. 222, for "17—," read "1769."

Page 252, no. 237, for "Malphigia" read "Malpighia."

Page 256, no. 321, for "Shumacher" read "Schumacher."

Page 258, no. 369, for "Nauv." read "Nouv."

Page 259, no. 384, for "Wetteranisch." read "Wetterauisch."

Page 262, line 11 from bottom, for "hausterium" read "haustorium."

Page 264, line 1, for "*oplhantha*" read "*lophantha.*"

Page 266, line 20, for "*corleay*" read "*corylea.*"

Page 272, last line, insert "see page 112."

Note.—The numbers occurring in the geographical distribution, and following certain host-plants, refer to published records, which will be found in the works of authors quoted under the respective number in the Bibliography; in all other cases, the occurrence of the species on the host-plants given, and its geographical distribution, have been personally verified.

INDEX.

(Synonyms in Roman; adopted specific and varietal names in Italics.)

Albigo calendulae, 51
drabae, 51
epilobii, 47
fugax, 47
humuli, 47
lanestris, 74
leucotricha, 40
mors-uvae, 70
Niesslii, 47
pannosa, 66
phytoptophila, 76
pruinosa, 47
tomentosa, 71

Alphitomorpha adunca var. amentacearum, 81
var. populi, 81
var. prunastri, 95
var. rosacearum, 95
var. ulmorum, 97
alni, 129
aphanis, 46
artemisiae, 194
astragali, 127
ballotae, 205
bardanae, 194
bicornis, 90
Brayana, 36
circumfusa, 194
clandestina var. alchemillae, 46
var. oxyacanthae, 30
comata, 125
communis, 174, 195
var. cichoracearum, 194
var. graminearum, 209
var. labiatarum, 205
var. personatarum, 50
corni, 213
cynoglossi, 194
depressa, 194
divaricata, 146
var. lonicerae, 142
epigaea, 237
epilobii, 46
epixylon, 237
euonymi, 125
ferruginea, 46
fuliginea, 49
fumosa, 50
grossulariae, 157
guttata, 225
heraclei, 175
holosericea, 127

Alphitomorpha horridula, 195
var. dryadearum, 46
var. spiraeacearum, 46
humuli, 46
hyperici, 174
labiatarum, 205
lamprocarpa, 205
var. balsaminae, 50
var. labiatarum, 205
var. plantaginis, 195
lenticularis, 225
macularis, 46
nitida, 175
obtusata, 81
pannosa, 65
penicillata, 129
var. alni, 129
var. berberidis, 123
var. caprifoliacearum, 143
var. grossulariae, 157
var. rhamni-cathartici, 129
pisi, 175
populi, 81
prunastri, 95
rosarum, 236
sericea, 127
tortilis, 213
tridactyla, 36
trifoliorum, 174
urticae, 174

Botrytis euphorbiae, 71

Calocladia, 121
berberidis, 124
comata, 126
divaricata, 147
Ehrenbergii, 143
Friesii, 130
grossulariae, 157
Hedwigii, 130
holosericea, 127
penicillata, 130

Dematium Erysiphe, 224

Erysibe, 237
acariforme, 237
aceris, 90, 93
adunca, 81
var. amentacearum, 81
var. populi, 81
var. prunastri, 95
var. rosacearum, 95

Erysibe aduncа, var. ulmorum, 97
alchemillae, 46
alni, 225
andraeacearum, 238
aphanis, 46
astragali, 127
berberidis, 123
bicornis, 90
biocellata, 194
Brayana, 36
chroolepidis, 238
cichoracearum, 196
circumfusa, 50, 194
clandestina, 30
comata, 125
communis, 50, 175, 194, 210
var. cichoracearum, 194
var. graminum, 209
var. labiatarum, 205
convolvuli, 175
coryli, 225
depressa, 194, 215
var. artemisiae, 194
divaricata, 123, 146
var. β, 123
var. frangulae, 146
var. lonicerae, 143
epilobii, 46
epimischa, 175
ferruginea, 46
fuliginea, 46, 50
fusca, 50
galeopsidis, 205
graminis, 210
guttata, 225
var. fagi, 225
heraclei, 176
holosericea, 127
horridula, 46, 195
var. ulmariae, 47
humuli, 46
lamprocarpa, 195, 205
var. balsaminae, 50
var. galeopsidis, 205
var. labiatarum, 205
var. plantaginis, 194
lenticularis, 225
var. carpini, 225
macropus, 174
macularis, 46
var. humuli, 46
myrtillina, 30
nitida, 176
obtusata, 81
orbicularis, 225
pachypus, 224
pannosa, 65
penicillata, 129
var. berberidis, 123
var. caprifoliacearum, 143
var. grossulariae 157.
pisi, 175
Erysibe polygoni, 175
populi, 81
potentillae, 46
pycnopus, 174
Sowerbii, 237
suffulta, 225
tortilis, 213
tridactyla, 36
Tuckeri, 99
ulmariae, 176

ERYSIPHE, 173
abnormis, 225
aceris, 90, 225
aduncа, 81, 95, 97
var. populi, 81
var. prunastri, 95
var. salicis, 81
var. ulmorum, 97
aggregata, 221
album, 236
alchemillae, 46
alhagi, 216
alni, 130, 224
ambrosiae, 195
aquilegiae, 174
arctii, 194
armata, 216
artemisiae, 194
asperifoliorum, 175, 194
asterum, 195
astragali, 127
bardanae, 194
berberidis, 123
betulae, 224
bicornis, 90, 93
bivonae, 98
capreae, 81
ceanothi, 130
cerasi, 225
chelones, 205
cichoracearum, 191, 193
clandestina, 30, 97
comata, 125
communis, 46, 50, 127, 175, 194, 205, 209
var. cichoracearum, 195
var. graminis, 209
var. graminum, 209
var. ulmariae, 177
var. umbelliferarum, 177
compositarum, 195, 215
convolvuli, 174
convolvuli-sepii, 176
corni, 214
coryli, 224
daphnes, 175
densa, 176
densissima, 129
detonsa, 51, 225
dipsacearum, 47
divaricata, 143, 146

Erysiphe divaricata, var. frangulae, 146
var. lonicerae, 143
doronici, 50
Duriaei, 216
erigerontis-canadensis, 50
erodii, 46
euonymi, 125
euphorbiae, 164
fagi, 225
ferruginea, 46
fraxini, 224
fuliginea, 46, 50
fungicola, 238
fusca, 50
fuscata, 51
galeopsidis, 197, 204
gerardiae, 50
gigantasca, 71
glomerata, 46
graminis, 209
grossulariae, 157
guttata, 225
var. mespili, 226
heraclei, 174
holosericea, 127
horridula, 196
var. cynoglossi, 196
humuli, 45
ilicis, 225
knautiae, 195
labiatarum, 205
lamprocarpa, 195, 205
var. galeopsidis, 205
var. plantaginis, 50, 196
lanata, 216
lanuginosa, 216
lappae, 216
lathyri, 175, 237
lenticularis, 225
lichenoides, 216
Linkii, 195
liriodendri, 175
lonicerae, 143
macularis, 176
mali, 225
marissalii, 225
Martii, 176
forma acaciae, 176
Montagnei, 196
mors-uvae, 70
Mougeotii, 159
myrtillina, 30
necator, 99
nervisequia, 238
nivea, 225
orontii, 195
oxyacanthae, 29, 224
pannosa, 65
papilionacearum, 216
pegani, 216
penicillata, 123, 129, 143, 157
var. berberidis, 123
Erysiphe penicillata, var. euonymi, 125
var. grossulariae, 157
var. lonicerae, 143
var. rhamni-frangulae, 146
Perisporium, 176
phlogis, 195
picridis, 215
pisi, 174
plantaginis, 50
polychaeta, 113
polygoni, 174, 176, 197
var. sepulta, 191
populi, 81, 82
poterii, 46
prunastri, 95
pyri, 225
quercinum, 130
quercus, 225
quisquiliarum, 205
radiosum, 236
ranunculi, 175, 176
robiniae, 175
roboris, 225
salicis, 81
sanguisorbae, 45
saxaouli, 216
saxifragae-sibericae, 237
scandens, 239
scandicis, 174
scorzonerae, 195
sepulta, 191
spadicea, 196
syringae, 130
taurica, 197, 215
tiliae, 237
tomentosa, 71
tordylii, 237
tortilis, 213
tridactyla, 36
trifolii, 175
trina, 223
Tuckeri, 99
ulmariae, 176
ulmi, 97
umbelliferarum, 176
vaccinii, 149
vagans, 224
varium, 81, 90, 174, 194, 224
var. suffultum, 224
verbenae, 195
vernalis, 176
viburni, 129, 130
xanthii, 50

Erysiphella aggregata, 221
Carestiana, 226
trina, 223

Erysiphopsis parnassiae, 177

Eurotium rosarum, 65

Meliola (Meliopsis) calendulae, 51

MICROSPHAERA, 121
abbreviata, 131
alni, 129, 131
var. *calocladophora*, 153
var. *divaricata*, 146
var. *extensa*, 152
var. *lonicerae*, 142
var. *ludens*, 154
var. *vaccinii*, 149
astragali, 127
Bäumleri, 170
berberidis, 123
Bornmuelleriana, 216
Bresadolae, 239
calocladophora, 154
caraganae, 177
coluteae, 164
comata, 125
densissima, 131, 153
diffusa, 161
divaricata, 146
Dubyi, 143
Ehrenbergii, 143
elevata, 149
erineophila, 131
euonymi, 125, 126
euphorbiae, 164
extensa, 152
ferruginea, 169
Friesii, 130
var. syringae, 130
var. vaccinii, 130
fulvofulcra, 30
grossulariae, 157
guarinonii, 167
Hedwigii, 130
holosericea, 127
lonicerae, 143
lycii, 160
marchica, 170
menispermi, 131
Mougeotii, 159
nemopanthis, 132
penicillata, 130
var. alni, 131
platani, 131
pulchra, 130
quercina, 132, 152
var. abbreviata, 132
var. extensa, 152
Ravenelii, 131
Russellii, 163
semitosta, 130
sparsa, 131
symphoricarpi, 161
umbilici, 168
vaccinii, 149
Van-Bruntiana, 157
viburni, 131

Mucor Erysiphe, 45, 90, 93, 174, 193, 204

Oidium, 26

Oidium aceris, 93
baleamii, 190, 191
farinosum, 44
leucoconium, 67
monilioides, 213
tabaci, 204
Tuckeri, 101–104
ventricosum, 75

Perisporium erysiphoides, 175

PHYLLACTINIA, 224
antarctica, 226
berberidis, 226
Candollei, 226
corylea, 224, 226
fungicola, 238
guttata, 226
Schweinitzii, 237
suffulta, 226
var. macrospora, 226

Pleochaeta Curtisii, 113, 115

PODOSPHAERA, 29
Aucupariae, 31
Bäumleri, 170
berberidis, 124
Bresadolae, 239
biuncinata, 39
Castagnei, 51
clandestina, 30
var. ramulicola, 30
comata, 126
epilobii, 47
grossulariae, 157
Hedwigii, 131
Kunzei, 30, 36
leucotricha, 40
minor, 30
Mougeotii, 159
myrtillina, 30
var. major, 31
oxyacanthae, 29, 30
var. *tridactyla*, 36
pannosa, 66
penicillata, 131
Schlechtendalii, 38
tridactyla, 36

Sclerotium Erysiphe, 45, 174, 224
var. corylea, 224
var. herbarum, 174
suffultum, 224

Sphaeria myrtillina, 30

SPHAEROTHECA, 44
calendulae, 51
Castagnei, 46, 50, 197
var. submutica, 51
var. vitis, 99
detonsa, 51
drabae, 51
epilobii, 47

Sphaerotheca erigerontis, 51
fugax, 47
gigantasca, 71
humuli, 45, 47, 48, 51
var. *fuliginea*, 49
lanestris, 74
leucotricha, 40
Mali, 40
mors-uv·e, 70
Niesslii, 47
pannosa, 65
phytoptophila, 76
pruinosa, 47
tomentosa, 71

UNCINULA, 79
aceris, 90
var. *Tulasnei*, 93
adunca, 81
var. artemisiae, 196
Americana, 99
ampelopsidis, 99
Australiana, 118
australis, 117
bicornis, 90
Bivonae, 98
circinata, 105

Uncinula *clandestina*, 97, 98
Clintonii, 109
Columbiana, 82
confusa, 115
Delavayi, 118
flexuosa, 108
fraxini, 119
geniculata, 111
heliciformis, 81
intermedia, 107
luculenta, 81
Lynchii, 113
macrospora, 107
necator, 99
parvula, 106
polychaeta, 113, 115
prunastri 95, 96
salicis, 81
var. epilobii, 82
var. *Miyabei*, 88
Sengokui, 120
spiralis, 99
var. racemosum, 99
subfusca, 99
Torreyi, 106
Tulasnei, 93
Wallrothii, 96

3 2044 103 103 172